BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-358154
(43)Date of publication of application : 26.12.2000

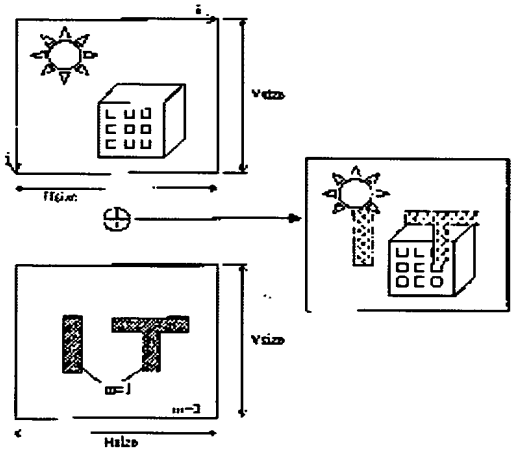
(51)Int.Cl. H04N 1/387
G06T 1/00
G09C 5/00

(21)Application number : 11-170816
(22)Date of filing : 17.06.1999

(71)Applicant : KOWA CO
(72)Inventor : MATSUI KINEO

(54) ELECTRIC WATERMARK CAPABLE OF ADJUSTING VISIBILITY OF WATERMARK

(57)Abstract:
PROBLEM TO BE SOLVED: To prepare picture data with a watermark expressing a color picture with a watermark by converting color picture data of a first color system to a second color system and inverting color picture data of the obtained second color system to the first color system through the use of an inversion matrix.
SOLUTION: In embedding a watermark to an original picture P, a mark picture M including a watermark to be embedded is prepared in addition to this picture P. This picture M is a binary picture and is converted from an RGB color system to a YCbCr color system first. A pixel at a position equivalent to the effective area of the watermark is converted by using an embedding conversion matrix obtained by adding an original conversion matrix and a watermark matrix. At the time of executing it concerning all the pixels, YCbCr picture data F with a watermark embedded with a digital watermark is obtained. At the time of operating an inversion matrix with respect to this YCbCr picture data F with watermark, RGB picture data P, with a watermark are obtained.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] It is the digital-watermarking method characterized by providing the following of spacing through a color picture and performing embedding of a mark. (a) A transformation matrix which changes color picture data of the 1st color coordinate system into color picture data of the 2nd different color coordinate system from said 1st color coordinate system, A production process which sets up an augmented matrix from which a production process for which an inverse transformation matrix which performs inverse transformation of said conversion is prepared, and (b) real number value x and -x are used as a component, and the sum of each line and a component of each train serves as abbreviation 0, (c) A production process which creates a transformation matrix for watermark embedding by adding said augmented matrix to said transformation matrix, a production process for which a watermark mark embedded in the (d) color picture is prepared, and a pixel equivalent to a location in the (e) aforementioned watermark mark A production process which changes color picture data of said 1st color coordinate system into said 2nd color coordinate system using said transformation matrix for watermark embedding (f) A production process where said watermark mark was embedded by transforming inversely color picture data of the 2nd color coordinate system acquired by said conversion to said 1st color coordinate system using said inverse transformation matrix, which spaces, is attached and expresses a color picture and which spaces, is attached and creates image data A preparation and said production process (b) are said real number value x. A production process which adjusts visibility of said said watermark [in / it is spaced and attached and / a color picture] mark by adjusting at least one side of the arrays of each component in said augmented matrix
[Claim 2] Adjustment of said visibility is the digital-watermarking method performed by setting said real number value x as a different value from other mark groups in some [at least] mark groups of said two or more mark groups including two or more mark groups from which it is the digital-watermarking method according to claim 1, and said watermark mark was separated spatially mutually.
[Claim 3] Adjustment of said visibility is the digital-watermarking method performed by setting it as a value which is [in / while it is the digital-watermarking method according to claim 1 and said watermark mark includes a mark field which consists of pixels which continued spatially, said mark field is classified into two or more partition fields, and / some / at least / partition fields of two or more of said partition fields] different from other partition fields in said real number value x.
[Claim 4] It is the digital-watermarking method performed when it is the digital-watermarking method according to claim 1 and adjustment of said visibility replaces the trains or lines of said augmented matrix.
[Claim 5] A digital-watermarking method characterized by providing the following It is the digital-watermarking method according to claim 1, and sets to said color picture with a watermark, and when said watermark mark can check by looking with the naked eye, said method is the product of the (g) aforementioned inverse transformation matrix and said augmented matrix further. A unit matrix which has a degree equal to said transformation matrix A production process for

which an invisibility-ized matrix which is an inverse matrix of **** is prepared (h) A production process at which visibility of a watermark mark in which said check by looking is possible is reduced in a pixel equivalent to a location in said watermark mark by [said] spacing, being attached and making image data operate said invisibility-ized matrix

[Claim 6] It is the digital-watermarking method which is the YCbCr color coordinate system by which it is the digital-watermarking method according to claim 1, one side of said the 1st and 2nd color coordinate system is an RGB system of color representation which consists of three chrominance-signal components showing three primary colors of light, and another side of said the 1st and 2nd color coordinate system is constituted from a luminance signal and two color-difference-signal components.

[Claim 7] It is the digital-watermarking method including a production process which performs underflow amendment and overflow amendment so that it is the digital-watermarking method according to claim 6, and said production process (f) may face image data of said YCbCr color coordinate system acquired by conversion by said transformation matrix for watermark embedding transforming inversely to said RGB system of color representation using said inverse transformation matrix and each pixel value in image data of said RGB system of color representation may turn into an integral value of a predetermined range.

[Claim 8] It is the digital-watermarking method that it is the digital-watermarking method according to claim 1, and said real number value x is a value of about 0.01 to about 0.7 range.

[Claim 9] It is the record medium which recorded a computer program for spacing through a color picture and performing embedding of a mark characterized by providing the following and in which computer reading is possible. A function to set up an augmented matrix from which a real number value x and -x are used as a component, and the sum of each line and a component of each train serves as abbreviation 0, A transformation matrix beforehand prepared in order to change color picture data of the 1st color coordinate system into color picture data of the 2nd different color coordinate system from said 1st color coordinate system, A function which spaces by adding said augmented matrix and creates a transformation matrix for embedding, and a pixel which was beforehand prepared using said transformation matrix for watermark embedding and which spaces and is equivalent to a location in a mark A function to change color picture data of said 1st color coordinate system into said 2nd color coordinate system A function which spaces, is attached and creates image data for said watermark mark to have been embedded by transforming inversely to said 1st color coordinate system using an inverse transformation matrix beforehand prepared in order to perform inverse transformation of conversion according color picture data of the 2nd color coordinate system acquired by said conversion to said transformation matrix and to space, and for it to be attached and to express a color picture A computer program for realizing a computer is recorded and said augmented-matrix setting up function is said real number value x. A function to adjust visibility of said said watermark [in / it is spaced and attached and / a color picture] mark by adjusting at least one side of the arrays of each component in said augmented matrix

---

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the digital-watermarking technology which spaces through a color picture and embeds a mark electronically.
[0002]
[Description of the Prior Art] With development of computer networks, such as the Internet, informational digitization progresses and the information which many users need simply can be accessed now. It is becoming the environment which refuses the author and can reproduce data easily [there is nothing and] on the other hand about the digital content which copyright has generated in the digital information, and the problem of the literary piracy accompanying an illegal copy has attracted attention. Then, the digital-watermarking technology which embeds watermark information, such as copyright information, to the data of a color picture for the purpose of preventing the literary piracy about the color picture which is the main information on a digital content etc. attracts attention.
[0003] About this conventional kind of digital watermarking, many technical proposals are made to the shade image. Since considering the brightness component (Y component) it can treat about a color picture as well as a shade image, the technique of embedding digital watermarking for the brightness component corresponding to a shade image has been used.
[0004]
[Problem(s) to be Solved by the Invention] However, most proposals which are going to use the signal and data of a proper for a color picture, and are going to embed digital watermarking are not made. "depths information record of a color picture" (the **** society --) which used the color space of a color printer as digital-watermarking embedding technology The collection of annual meeting drafts, 7 and 20, pp.47-48, "a way method of the color watermark in consideration of a vision property" (IMPS 97, I-3.14, pp.45-46 (1997)) of model style molding which used the vision property skillfully, "A way method of the digital-watermarking embedding to a digital image" (SITA 97, Vol.2, pp.541-544 (1997)) is proposed. Such technology has a complicated model and has the weak spot where pad processing of a watermark is not easy. Moreover, degrading the image quality of a color picture was also pointed out by the method of embedding a watermark at the lower bit of a color picture.
[0005] This invention aims at offering the digital-watermarking technology for spacing through a color picture using the property of a proper, and embedding a mark.
[0006]
[The means for solving a technical problem, and its operation and effect] In this invention, the transformation matrix which changes the color picture data of the 1st color coordinate system into the color picture data of the 2nd different color coordinate system from the 1st color coordinate system, and the inverse transformation matrix which performs inverse transformation of the conversion are prepared. Moreover, the augmented matrix from which the real number value x and -x are used as a component, and the sum of each line and the component of each train serves as abbreviation 0 is set up. And the transformation matrix for watermark embedding is created by adding an augmented matrix to a transformation matrix. Next, the watermark mark

embedded in a color picture is prepared, and the color picture data of the 1st color coordinate system is changed into the 2nd color coordinate system in the pixel equivalent to the location in a watermark mark using the transformation matrix for watermark embedding. The image data with a watermark showing the color picture with a watermark where the watermark mark was embedded is created by transforming inversely the color picture data of the 2nd color coordinate system acquired by this conversion to the 1st color coordinate system using an inverse transformation matrix. Moreover, it is spaced and attached by adjusting at least one of the real number value x and the arrays of each component in an augmented matrix in the case of a setup of an augmented matrix, and the visibility of the watermark mark in a color picture is adjusted.

[0007] In this invention, by performing conversion and inverse transformation using a transformation matrix, and the inverse transformation matrix and augmented matrix between two color coordinate systems, it can space through a color picture and a mark can be embedded. If the value of the real number value x which specifies the component of an augmented matrix changes, the color of a watermark mark will change. Moreover, it spaces also by modification of the array of each component of an augmented matrix, and the color of a mark changes. Therefore, it is possible by adjusting at least one of the value of the real number value x of an augmented matrix, and the arrays of each component in an augmented matrix to adjust the visibility of a watermark mark.

[0008] Here, the YCbCr color coordinate system which makes a parameter the RGB system of color representation, luminance signal, and color-difference signal which make the three primary colors of light a parameter as the 1st or 2nd color coordinate system is employable suitably. These color coordinate systems are what is often used when treating image data, and a mutual transformation matrix is known well. Therefore, much retouching software which deals with future image data exists, and digital watermarking can be embedded simple.

[0009] In addition, the watermark mark may contain two or more mark groups separated spatially mutually. At this time, visibility can be adjusted in some [at least] mark groups of two or more mark groups by setting the real number value x as a different value from other mark groups. If it carries out like this, it is possible to embed two or more mark groups from which visibility differs in a color picture.

[0010] Moreover, the watermark mark may be classified into the partition field of plurality [field / mark] with ** in the mark field which consists of pixels which continued spatially. At this time, visibility can be adjusted in some [at least] partition fields of two or more partition fields by setting the real number value x as a different value from other partition fields. If it carries out like this, it is possible to embed a watermark mark which includes the mark field which consisted of two or more partition fields in which visibility differs in a color picture.

[0011] Adjustment of visibility can be carried out by replacing the trains or lines of said augmented matrix. If it carries out like this, it is possible to only set a watermark mark as desired visibility by exchange of trains or lines.

[0012] In addition, it is also possible to space, for it to be attached, to space in a color picture, and to reduce the visibility of a watermark mark when a mark can check by looking with the naked eye. Under the present circumstances, the product of an inverse transformation matrix and said augmented matrix, a transformation matrix and the unit matrix which has an equal degree, and the invisibility-ized matrix that is an inverse matrix of the sum of ** are prepared first. And in the pixel equivalent to the location in a watermark mark, the visibility of the watermark mark which can be checked by looking is reduced by being spaced and attached and making image data operate an invisibility-ized matrix.

[0013] Furthermore, it is desirable to face [transforming inversely to said RGB system of color representation using an inverse transformation matrix] the image data of the YCbCr color coordinate system acquired by conversion by the transformation matrix for watermark embedding, and to perform underflow amendment and overflow amendment so that each pixel value in the image data of an RGB system of color representation may turn into an integral value of a predetermined range. If it carries out like this, the result of having transformed inversely can be dedicated within limits which the image data of an RGB system of color representation can take.

[0014] As for the real number value x of an augmented matrix, it is desirable to set it as the value of about 0.01 to about 0.7 range. If it carries out like this, since the incidence rate of underflow amendment or overflow amendment can be stopped small, deterioration of the substantial image quality by the embedding of a watermark mark can be reduced.
[0015] In addition, this invention is realizable in various modes, such as a computer program for realizing the function of the digital-watermarking method and equipment, its method, or equipment, a record medium which recorded the computer program, and a data signal embodied in the subcarrier including the computer program.
[0016]
[Embodiment of the Invention] A. Embedding processing of digital watermarking, and the principle of decode processing : explain the gestalt of operation of this invention hereafter based on an example. Drawing 1 is explanatory drawing of the principle of embedding processing of digital watermarking to the digital color picture in an example. Moreover, drawing 2 is explanatory drawing showing the contents of embedding processing.
[0017] Drawing 2 (A) shows the digital color picture which is a subject-copy image expressed by the RGB system of color representation. This subject-copy image P is defined as the aggregate of the pixel of a large number arranged in the shape of a matrix, and the magnitude of the subject-copy image P is prescribed by horizontal resolution Hsize and vertical definition Vsize. In addition, the unit of horizontal resolution or vertical definition is the number of pixels.
[0018] In this specification, the image data showing the color of each pixel of the subject-copy image P is defined by matrix =[P] [r, g, b] t (the alphabetic character with a top "t" shows a transposed matrix). the red (r) r, g, and whose b are the three primary colors of light here -- green -- (g) and blue (b) -- it is the brightness of each color component. The brightness of each color is expressed with predetermined resolution (for example, 256 gradation from zero to 255). Moreover, the YCbCr color coordinate system which specifies the color of each pixel and which consists of the luminance signal and two color-difference signals other than an RGB system of color representation if a color coordinate system is carried out is known widely. The image data which expresses the color of each pixel by the YCbCr color coordinate system in this specification is matrix =[F] [y, cb, cr] t. It defines.
[0019] These two color coordinate systems can be mutually changed reversibly by the chrominance-signal transformation matrix A and its inverse matrix A-1, as shown in the following (1a) and a formula (1b).
[0020]
[Equation 1]

$$F(i,j)=AP(i,j) \qquad (1a)$$

$$P(i,j)=A^{-1}F(i,j) \qquad (1b)$$

[0021] here, chrominance signals P and F are given -- **** (i, j) -- the location of a pixel is meant.
[0022] In this example, what is given by the following (2a) and the (2b) formula as a transformation matrix A and an inverse transformation matrix A-1 is used.
[0023]
[Equation 2]

$$A=\begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \qquad (2a)$$

$$A^{-1}=\begin{bmatrix} 1.000 & -0.001 & 1.402 \\ 1.000 & -0.344 & -0.714 \\ 1.000 & 1.772 & 0.001 \end{bmatrix} \qquad (2b)$$

[0024] In this example, it spaces, in case image data P of an RGB system of color representation is changed into image data F of a YCbCr color coordinate system, a mark is embedded, by

transforming this inversely to an RGB system of color representation again, it is spaced and attached and an image is created. the transformation matrix (it is called "the transformation matrix for embedding") used for the embedding of a watermark mark is a thing (namely, (A+X)) adding the augmented matrix X given to a transformation matrix A by the following (3) formulas.
[0025]
[Equation 3]

$$X=\begin{bmatrix} 0 & -x & x \\ x & 0 & -x \\ -x & x & 0 \end{bmatrix} \qquad (3)$$

ここで、xは実数値である。

[0026] This augmented matrix X is a matrix in which the real number value x and −x are used as a component, and the sum of each line and the component of each train is set to 0. In addition, in this specification, a "watermark value" also calls a call and an augmented matrix X a "watermark matrix" for this real number value x. It opts for the configuration of such a watermark matrix X for the following reasons. First, it considers embedding so that a watermark mark cannot be checked by looking with the naked eye. For this reason, it is desirable to prevent the image quality deterioration by the pad of a watermark as much as possible. By the way, when each component of the transformation matrix A given by the formula (2a) is observed, it turns out that all the sums of the absolute value of the component of each line are 1. Therefore, also in the transformation matrix (A+X) for embedding, it is desirable to hold relation in which the sum of the absolute value of the component of each line is set to 1, when preventing image quality deterioration. (3) Since the watermark matrix X of a formula is set up so that the sum of each line and the component of each train may be set to 0, such a demand has been satisfied.
[0027] In case it spaces through the subject-copy image P and a mark is embedded, the mark image M which should be embedded and which spaces and includes a mark is prepared besides this subject-copy image P. An example of the mark image M used by this example is shown in drawing 2 (B). This mark image M is a binary image, the pixel value m in the field of two alphabetic characters "I" which constitute a watermark mark, and "T" is 1, and the pixel value m in other fields is 0. Below, the pixel value m only calls "the service area of a watermark mark", or a "mark field" and the field a call and whose pixel value m are 0 "the non-service area of a watermark mark" for the field which is 1. In addition, the service area of a watermark mark may only be called a "watermark mark." For example, the **** "the location in a watermark mark" has the same semantics as "the location in the service area of a watermark mark."
[0028] The mark image M of this example has the same size as the subject-copy image P. However, the necessity of having the same size as the subject-copy image P does not have the mark image M, and the location of a watermark mark embedded in the subject-copy image M should just be determined by a certain method.
[0029] In case a watermark mark is embedded, according to the following (4a) and a formula (4b), conversion to a YCbCr color coordinate system from an RGB system of color representation is performed first.
[0030]
[Equation 4]

$$F_X(i,j)=(A+X)P(i,j) \quad ;m(i,j)=1 \qquad (4a)$$

$$F_X(i,j)=AP(i,j) \quad ;m(i,j)=0 \qquad (4b)$$

[0031] that is, in the pixel (pixel of m(i, j) = 1) of the location equivalent to the service area of a watermark mark, it spaced with the original transformation matrix A, and Matrix X was added -- embedding -- business -- conversion of a color coordinate system is performed using a transformation matrix (A+X). On the other hand, conversion of a color coordinate system is performed in the pixel (pixel of m(i, j) = 0) of the location equivalent to the non-service area of a watermark mark, using the original transformation matrix A as it is.
[0032] watermark information was embedded when data processing by (4a) and the formula (4b)

was performed to all pixels -- spacing -- being attached -- YCbCr image data FX It is obtained (drawing 1 , drawing 2 (C)).
[0033] Next, this YCbCr image data FX with a watermark RGB-image-data PX with a watermark which will be given by the following (5a) and the formula (5b) if it receives and the inverse transformation matrix A-1 is made to operate it from the left It is obtained (drawing 1).
[0034]
[Equation 5]

$$P_X(i,j)=A^{-1}(A+X)P(i,j)$$
$$=P(i,j)+A^{-1}XP(i,j) \quad ;m(i,j)=1 \quad (5a)$$
$$P_X(i,j)=A^{-1}AP(i,j)$$
$$=P(i,j) \quad ;m(i,j)=0 \quad (5b)$$

[0035] It is spaced and attached as shown in this (5a) formula, and it is RGB-image-data PX. Original RGB-image-data P is overlapped on a noise component (A-1XP) in the service area of a watermark mark. Moreover, it is spaced and attached in the non-service area of a watermark mark, and is RGB-image-data PX. It has the value equal to original RGB-image-data P.
[0036] By the way, the sum of the component of each line of the watermark matrix X is 0 as shown in the above-mentioned (3) formula. Therefore, when the value of r of original RGB-image-data P (i, j), g, and b component is mutually equal (at namely, the time of an achromatic color), the noise component (A-1XP) of a formula (5a) will be set to 0. In order to prevent such a problem, as for a watermark mark, it is desirable to position to the field which is not an achromatic color in a subject-copy image.
[0037] In addition, drawing 2 (C) shows the condition that it is spaced and attached and the watermark mark in an image looks [****] thin. However, the visibility (the ease of carrying out of recognition by the naked eye) of a watermark mark can be adjusted by adjusting the watermark value x in the watermark matrix X in fact. About the method of adjustment of the visibility of a watermark mark, it mentions later further.
[0038] By the way, usually YCbCr image data consists of real number values to RGB image data consisting of integral values. Therefore, in case it changes into a YCbCr color coordinate system by (4a) and the formula (4b), real number-ization is performed, and integer-ization is performed in case it transforms inversely to an RGB system of color representation by (5a) and the formula (5b). In the case of this integer-izing, the case where a pixel value serves as negative and an underflow is generated, and the case where it is overflowed exceeding the maximum of a pixel value occur. In order to solve this problem, in this example, underflow amendment and overflow amendment are performed in the case of integer-izing. That is, in performing underflow amendment set to 0 when the pixel value before integer-izing becomes negative, and exceeding the upper limit (for example, 255) of the bit expression, it performs overflow amendment which adopts the upper limit.
[0039] If underflow amendment and overflow amendment are performed, it will be spaced and attached and the substantial image quality of an image will be degraded. Here, "substantial deterioration" means deterioration of the image quality which cannot be recovered even if it eliminates a watermark mark. Since it originates in having spaced underflow amendment and overflow amendment through the original transformation matrix A, and having added Matrix X, the incidence rate of underflow amendment or overflow amendment spaces, and is dependent on the watermark value x which is the component of Matrix X. Therefore, as for the watermark value x, it is desirable to set it as a value which underflow amendment and overflow amendment seldom generate.
[0040] Drawing 3 is explanatory drawing showing the relation between the watermark value x and the incidence rate of underflow amendment and overflow amendment. "girl" and "graphic" which are the standard image used for the characterization of image quality here The result related with two images is shown. In addition, it is thought that results differ by the case where it is the case where the watermark value x is 0.1, and -0.1 because a bias is in distribution of the

components r, g, and b of three colors in an image. The result of drawing 3 shows that it is desirable to set the watermark value x as about 0.7 or less value, in order to stop low the incidence rate of underflow amendment and overflow amendment. In addition, since it cannot space if the watermark value x is set as 0, and a mark cannot be embedded, it is desirable to set the watermark value x as about 0.01 or more values in fact. Therefore, it is desirable to set it as the value of about 0.01 - about 0.7 range as a watermark value x.

[0041] By the way, when [which it spaces and a mark cannot recognize with the naked eye] embedded, it will be necessary to restore the watermark mark. By being able to recognize with the naked eye, and twisting and spacing, a mark spaces, and it is attached, and is RGB-image-data PX. By using the noise component (A-1XP) contained, decoding by the following various methods is possible.

[0042] The 1st method is a method of performing color modification processing of an image so that it may be spaced and attached and the brightness value of each components r, g, and b of a RGB image may be raised to near the maximum. If it carries out like this, since a noise component (A-1XP) will also become large, it becomes easy to recognize a watermark mark with the naked eye.

[0043] The 2nd method is spaced, is attached and is RGB-image-data PX. It is the method of using the noise component (A-1XP) contained directly. That is, it is spaced and attached, using the subject-copy image data P as a key, and is RGB-image-data PX. A watermark mark (namely, watermark information) can be decoded by determining the field which sets and has a noise component (A-1XP). It is spaced and attached and, specifically, is RGB-image-data PX. It is possible to ask for difference (PX-P) with original RGB-image-data P, and to determine the field this difference (PX-P) of whose is not 0 as a mark field. In addition, difference (PX-P) is a matrix which has three components, r, g, and b, and **** "difference (PX-P) is not 0" means that at least one of the three components is not 0.

[0044] In addition, if the noise component (A-1XP) in a mark field is made to operate a transformation matrix A from the left, the product (XP) of the watermark matrix X and the subject-copy image data P will be obtained. If the subject-copy image data P is known, also when the watermark value x is unknown, it is possible to space from this product (XP) and to decode the watermark value x of Matrix X.

[0045] As mentioned above, a watermark mark can be embedded in a color picture by [which spaced through the transformation matrix A and added Matrix X] embedding and using the transformation matrix (A+X) of business. Moreover, the thing which it spaced, and it was attached and was embedded from the image and which space and restores a mark is also possible.

[0046] B. adjustment [of the visibility of a watermark mark]: -- it mentioned above -- as -- spacing -- being attached -- RGB image PX **** -- in the mark field, it is superimposed on the noise component (A-1XP). Therefore, it is possible by adjusting the magnitude of the watermark value x and changing the value of a noise component (A-1XP) to adjust the visibility of a watermark mark.

[0047] Drawing 4 is explanatory drawing showing the adjustment method of the visibility of a watermark mark. The subject-copy image P of drawing 4 (A) and the mark image M of drawing 4 (B) are the same as what was shown in drawing 2 (A) and (B).

[0048] If the watermark value x is set as about about 0.7 comparatively big value, as shown in drawing 4 (C), it is spaced and attached and the watermark mark in an image can recognize clearly with the naked eye. Such a watermark mark is called "a visible watermark" on these specifications. If it spaces through a field with little change of color and a mark exists especially, change of the color in a mark field can be recognized more clearly. Therefore, in order to make a watermark mark easy to check by looking, it is desirable to space through a field with little change of color, and to position a mark.

[0049] When the watermark value x is set as about about 0.05 comparatively small value, it is spaced and attached and it becomes impossible on the other hand, for the watermark mark in an image to recognize with the naked eye, as shown in drawing 4 (E). Such a watermark mark is called "an invisible watermark" on these specifications. In addition, although the dotted line

shows the appearance of a mark field in drawing 4 (E) in order to show the location of a watermark mark, it is possible to space through the degree which can hardly be recognized with the naked eye in fact, and to invisibility-ize a mark. Especially, lightness is in the orientation which cannot check a watermark mark by looking easily in a low field and the field of the chromatic color near an achromatic color. Therefore, in order to make a watermark mark hard to check by looking, it is desirable to space through the field where lightness is low, and the field of the chromatic color near an achromatic color, and to position a mark.

[0050] If the watermark value x is set as the in-between value of a visible watermark and an invisible watermark, a translucent watermark (it is called "a half-visible watermark") is generable. For example, if the watermark value x is set as about about 0.3 value, as shown in drawing 4 (D), it will be spaced and attached and the watermark mark in an image will become translucent.

[0051] Thus, it is possible by setting the watermark value x as a suitable value to set the visibility of a watermark mark as a desired degree.

[0052] By the way, it is possible by adjusting the array of the watermark matrix X to adjust the color of a watermark mark instead of adjusting the watermark value x as mentioned above. Namely, watermark matrix [1 and 3] 1 and X 2X which spaces and is illustrated by the following (6) types and (7) types instead of Matrix X as shown in (3) types If embedding processing used and mentioned above is performed, the color of a watermark mark will be changed.

[0053]

[Equation 6]

$$X_{1,2}=\begin{bmatrix} x & 0 & -x \\ 0 & -x & x \\ -x & x & 0 \end{bmatrix} \qquad (6)$$

[0054]

[Equation 7]

$$X_{1,3}=\begin{bmatrix} x & -x & 0 \\ -x & 0 & x \\ 0 & x & -x \end{bmatrix} \qquad (7)$$

[0055] (6) Watermark matrix 1 and X 2 of a formula The 1st line of the watermark matrix X of (3) types and the 2nd line are replaced. Moreover, watermark matrix 1 and X 3 of (7) types The 1st line of the watermark matrix X of (3) types and the 3rd line are replaced. Generally it is possible by replacing the trains or lines of the watermark matrix X to change the color of a watermark mark so that these examples may show. In addition, if the color of a watermark mark is changed, the ease (namely, visibility) of carrying out of recognition by the naked eye will also change in many cases. So, on these specifications, changing the color of a watermark mark also corresponds to "adjustment of visibility" by replacing the trains or lines of a watermark matrix in this way.

[0056] C. Invisibility-ized processing of a visible watermark : a visible watermark can be invisibility-ized by processing of further the following. It is spaced and attached that a watermark mark can recognize with the naked eye so that he can understand from the formula (5a) mentioned above, and it is image data PX. It is because the noise component (A-1XP) is comparatively large. Therefore, it is possible to invisibility-ize a visible watermark by performing processing which reduces a noise component (A-1XP). In the case of this invisibility-ized processing, the invisibility-ized matrix K given by the following (8) formulas is used.

[0057]

[Equation 8]

$$K=(I+A^{-1}X)^{-1} \qquad (8)$$

[0058] Here, I is the unit matrix of 3x3. That is, the invisibility-ized matrix K is the unit matrix I and the inverse matrix of the sum (I+A-1X) of ** which space with the inverse transformation

matrix A-1, and have the product (A-1X) of Matrix X, and a degree equal to a transformation matrix A.

[0059] About this invisibility-ized matrix K, as shown in drawing 5 , it is RGB-image-data PX with a watermark of a formula (5a). If it is operated, that addition result will be given by the following (9) formulas.

[0060]

[Equation 9]

$$K P_X(i,j) = (I + A^{-1}X)^{-1}(I + A^{-1}X)P(i,j)$$
$$= P'(i,j)$$
$$\cong P(i,j) \qquad (9)$$

[0061] Here, that the right-hand side of the 2nd line of (9) types is P' (i, j) means that it may not return to original image data P (i, j) completely according to the operation error in the middle of the embedding processing mentioned above (rounding error). That is, since integer-ization is performed when transforming inversely from a YCbCr signal to an RGB code, image data P' after invisibility-izing (i, j) may be unable to acquire the completely same value as the subject-copy image data P (i, j). However, since the error is a small amount below decimal point, with the naked eye, it is visible to the condition of not being different from a subject-copy image. [of the image after invisibility-izing] However, when the error by overflow amendment or underflow amendment is big, even if it performs invisibility-ization, it becomes impossible to return color to a dimension, and the trace of a watermark mark may be able to be checked by looking. Therefore, in order to be able to carry out [invisibility]-izing as completely as possible, it is desirable to use the small watermark value x of the degree which generates neither overflow amendment nor underflow amendment not much.

[0062] In addition, since image data P' after invisibility-izing includes the error in the mark field, it can decode a watermark mark also from image data P' after invisibility-izing. For example, image data P' after invisibility-izing and difference (P' - P) with the subject-copy image data P can be taken, and this difference (P' - P) can determine in 0 the field which is not as a mark field.

[0063] E. Improvement measure in security : one watermark value x was used for the whole watermark mark in above-mentioned explanation. When a third person gets to know the watermark value x temporarily, there is a possibility of a watermark of a false being created or changing a watermark mark easily. Then, in order to strengthen the security of digital watermarking, it is desirable to apply two or more watermark values x in a mark image.

[0064] Drawing 6 is explanatory drawing showing the example which applied two or more watermark values x in the mark image. A different watermark value x1 to the mark field of two alphabetic characters "I" and "T" which constitutes a watermark mark from drawing 6 (A), and x2 It is applied. Moreover, a watermark value x1 which 2 sets of mark groups spatially separated in the mark image are arranged in drawing 6 (B), and is different to these two mark groups and x2 It is applied. In addition, it is also possible to consider that an alphabetic character "I" and "T" are a mutually different mark group also in the case of drawing 6 (A). That is, it is possible to set up a mutually different watermark value x to two or more mark groups generally separated spatially mutually. Since the visibility of a watermark mark changes according to the watermark value x as mentioned above, it is possible for it to be spaced and attached and to embed the mark group of various visibility in an image by setting up a watermark value x which is different in two or more mark groups in a mark image.

[0065] Drawing 7 is explanatory drawing showing the example of a partition of the mark field for a multiplex watermark. In the example of drawing 7 , the mark field which consists of one alphabetic character "T" is classified into two or more partition fields, and a different watermark value x is applied to the adjoining partition field. Various methods, such as the method of classifying with parallel lines like drawing 7 (A) as the partition method of a mark field and the method of classifying with a multiplex contour line-like border line like shown in drawing 7 (B), can be considered. In addition, "one mark field" means the service area which consists of pixels

which continued spatially.
[0066] Since the watermark value x applied to each partition field can be kept secret by such multiplex watermark method, it is able for a third person to space and to prevent to discover a value x easily.
[0067] F. Whole equipment configuration and procedure : drawing 8 is the block diagram showing the configuration of the digital-watermarking processor which performs above-mentioned digital-watermarking processing by this example. This digital-watermarking processor is a computer equipped with CPU22, the main memory 24 containing ROM and RAM, a frame memory 26, a keyboard 30, a mouse 32, an indicating equipment 34, a hard disk 36, a modem 38, the scanner 39 that reads an image, and the bus 40 which connects each of these elements. In addition, various kinds of interface circuitries are omitted in drawing 8 . The modem 38 is connected to the computer network through the communication line which is not illustrated. The server which a computer network does not illustrate has a function as a program feeder which supplies a computer program to a digital-watermarking processor through a communication line.
[0068] The computer program for realizing the function of the digital-watermarking embedding section 42, the digital-watermarking decode section 44, the watermark visualization section 46, and ** is stored in main memory 24. It is as having spaced with the digital-watermarking embedding section 42 and the digital-watermarking decode section 44, and having already explained the function of the visualization section 46 in detail.
[0069] The computer program which realizes the function of these each part 42, 44, and 46 is offered with the gestalt recorded on the record medium which a flexible disk, CD-ROM, etc. can computer read. A computer reads a computer program in the record medium, and transmits it to internal storage or external storage. Or you may make it supply a computer program to a computer through a communication path. When realizing the function of a computer program, the computer program stored in internal storage is executed by the microprocessor of a computer. Moreover, a computer reads the computer program recorded on the record medium, and it may be made to carry out immediate execution.
[0070] In this specification, a computer is a concept containing hardware and operation system, and means the hardware which operates under control of operation system. Moreover, operation system is unnecessary, and when it seems that hardware is operated by the application program independent, the hardware itself is equivalent to a computer. Hardware is equipped with microprocessors, such as CPU, and the means for reading the computer program recorded on the record medium at least. The computer program contains in such a computer the program code which realizes the function of each above-mentioned means. In addition, a part of above-mentioned function may be realized by not an application program but operation system. Furthermore, the program which performs embedding processing of digital watermarking, decode processing, and invisibility-ized processing of a watermark is good also as what is added in the form of plug-in to the program which performs an image processing.
[0071] In addition, as a "record medium" in this invention, computers, such as internal storage (memory, such as RAM and ROM) of the printed matter with which signs, such as a flexible disk, CD-ROM and a magneto-optic disk, an IC card, a ROM cartridge, a punch card, and a bar code, were printed, and a computer, and external storage, can use various data medium in which read is possible.
[0072] Drawing 9 is a flow chart which shows the procedure of the embedding processing which the embedding section 42 of digital watermarking performs. At step S1, the original RGB image P and the mark image M are prepared. At step S2, the transformation matrix A used for conversion of a color coordinate system and its inverse transformation matrix A-1 are prepared. At step S3, the watermark matrix X and the watermark value x are set up, respectively. In addition, a user is able to perform various setup which includes the adjustment of the visibility space and according to the value of a value x mentioned above, adjustment of the visibility by exchange of the lines of the watermark matrix X, or trains, and a setup of two or more watermark values x which can be set in a mark image at step S3.
[0073] At step S3, embedding processing mentioned above is performed using the transformation matrix (A+X) for embedding, and the inverse transformation matrix A-1. It is spaced and

attached and an image is expressed on a display 34 as step S5. or it spaces, and it is attached and you may make it print an image by the printer which is not a drawing example At step S6, it spaces, it is attached and an image is observed, and if a user is this thing that can satisfy a result, he will end embedding processing. When it cannot be satisfied with a result, it spaces through step S3 with return and the watermark matrix X, a setup of a value x is changed, and step S4 and S5 are performed again. In this way, the thing for which the watermark mark of desired visibility was embedded and which spaces, are attached and creates an image is possible by repeating steps S3-S6.

[0074] in addition, as for decode of the watermark mark by the watermark decode section 44 (drawing 8), and invisibility-izing of the visible watermark by the watermark invisibility-ized section 46, the watermark mark was embedded -- it spaces, and it is attached and performs to an image if needed. Explanation of such procedure is omitted.

[0075] In addition, this invention can be carried out in various modes in the range which is not restricted to an above-mentioned example or an above-mentioned operation gestalt, and does not deviate from that summary, for example, the following deformation is also possible for it.

[0076] (1) You may make it transpose a part of configuration of that hardware was realized to software, and may make it transpose a part of configuration of that reverse was realized by software to hardware in the above-mentioned example. For example, it is also possible to space with the digital-watermarking embedding section 42 and the digital-watermarking decode section 44 which were realized by the computer program in drawing 8 , and to realize the function of the visualization section 46 by the hardware circuitry of respectively dedication.

[0077] (2) Although it spaced by transforming inversely once changing into a YCbCr color coordinate system from an RGB system of color representation and embedding of a mark was performed in the above-mentioned example, with this, embedding may be performed by transforming inversely conversely, once changing into an RGB system of color representation from a YCbCr color coordinate system. Moreover, it is possible to use two color coordinate systems of the arbitration which can perform reversibly not only these two color coordinate systems but conversion and inverse transformation as a color coordinate system which can be used.

[0078] (3) In the above-mentioned example, although conversion and inverse transformation were performed also with the pixel in the non-service area of a watermark mark using the transformation matrix A and the inverse transformation matrix A-1, respectively at the time of the embedding of a watermark mark, since it will return to subject-copy image data if inverse transformation is performed about a non-service area, it may not be made not to perform such conversion or inverse transformation. In this case, by [which space and compounds the image data in a mark field to the subject-copy image data P (namely, overwrite)] having performed embedding processing mentioned above and having been obtained in this way about the service area of a watermark mark, it is spaced and attached and is image data PX. The whole can be obtained. What is necessary is just to perform inverse transformation using the conversion which used the transformation matrix (A+X) for embedding, and the inverse transformation matrix A-1 on the occasion of the embedding of a watermark mark about the pixel which spaces at least and is equivalent to the location in the service area of a mark, if it puts in another way.

[0079] (4) Although the above-mentioned example showed the example by which the watermark mark is constituted from a character string, as a watermark mark, it is possible to use the objects (natural drawing, an illustration, LOGO, etc.) of arbitration other than a character string.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[The technical field to which invention belongs] This invention relates to the digital-watermarking technology which spaces through a color picture and embeds a mark electronically.

[Translation done.]

* NOTICES *

PRIOR ART

[Description of the Prior Art] With development of computer networks, such as the Internet, informational digitization progresses and the information which many users need simply can be accessed now. It is becoming the environment which refuses the author and can reproduce data easily [there is nothing and] on the other hand about the digital content which copyright has generated in the digital information, and the problem of the literary piracy accompanying an illegal copy has attracted attention. Then, the digital-watermarking technology which embeds watermark information, such as copyright information, to the data of a color picture for the purpose of preventing the literary piracy about the color picture which is the main information on a digital content etc. attracts attention.
[0003] About this conventional kind of digital watermarking, many technical proposals are made to the shade image. Since considering the brightness component (Y component) it can treat about a color picture as well as a shade image, the technique of embedding digital watermarking for the brightness component corresponding to a shade image has been used.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[The means for solving a technical problem, and its operation and effect] In this invention, the transformation matrix which changes the color picture data of the 1st color coordinate system into the color picture data of the 2nd different color coordinate system from the 1st color coordinate system, and the inverse transformation matrix which performs inverse transformation of the conversion are prepared. Moreover, the augmented matrix from which the real number value x and −x are used as a component, and the sum of each line and the component of each train serves as abbreviation 0 is set up. And the transformation matrix for watermark embedding is created by adding an augmented matrix to a transformation matrix. Next, the watermark mark embedded in a color picture is prepared, and the color picture data of the 1st color coordinate system is changed into the 2nd color coordinate system in the pixel equivalent to the location in a watermark mark using the transformation matrix for watermark embedding. The image data with a watermark showing the color picture with a watermark where the watermark mark was embedded is created by transforming inversely the color picture data of the 2nd color coordinate system acquired by this conversion to the 1st color coordinate system using an inverse transformation matrix. Moreover, it is spaced and attached by adjusting at least one of the real number value x and the arrays of each component in an augmented matrix in the case of a setup of an augmented matrix, and the visibility of the watermark mark in a color picture is adjusted.
[0007] In this invention, by performing conversion and inverse transformation using a transformation matrix, and the inverse transformation matrix and augmented matrix between two color coordinate systems, it can space through a color picture and a mark can be embedded. If the value of the real number value x which specifies the component of an augmented matrix changes, the color of a watermark mark will change. Moreover, it spaces also by modification of the array of each component of an augmented matrix, and the color of a mark changes. Therefore, it is possible by adjusting at least one of the value of the real number value x of an augmented matrix, and the arrays of each component in an augmented matrix to adjust the visibility of a watermark mark.
[0008] Here, the YCbCr color coordinate system which makes a parameter the RGB system of color representation, luminance signal, and color-difference signal which make the three primary colors of light a parameter as the 1st or 2nd color coordinate system is employable suitably. These color coordinate systems are what is often used when treating image data, and a mutual transformation matrix is known well. Therefore, much retouching software which deals with future image data exists, and digital watermarking can be embedded simple.
[0009] In addition, the watermark mark may contain two or more mark groups separated spatially mutually. At this time, visibility can be adjusted in some [at least] mark groups of two or more mark groups by setting the real number value x as a different value from other mark groups. If it carries out like this, it is possible to embed two or more mark groups from which visibility differs in a color picture.
[0010] Moreover, the watermark mark may be classified into the partition field of plurality [field / mark] with ** in the mark field which consists of pixels which continued spatially. At this time, visibility can be adjusted in some [at least] partition fields of two or more partition fields by setting the real number value x as a different value from other partition fields. If it

carries out like this, it is possible to embed a watermark mark which includes the mark field which consisted of two or more partition fields in which visibility differs in a color picture.
[0011] Adjustment of visibility can be carried out by replacing the trains or lines of said augmented matrix. If it carries out like this, it is possible to only set a watermark mark as desired visibility by exchange of trains or lines.
[0012] In addition, it is also possible to space, for it to be attached, to space in a color picture, and to reduce the visibility of a watermark mark when a mark can check by looking with the naked eye. Under the present circumstances, the product of an inverse transformation matrix and said augmented matrix, a transformation matrix and the unit matrix which has an equal degree, and the invisibility-ized matrix that is an inverse matrix of the sum of ** are prepared first. And in the pixel equivalent to the location in a watermark mark, the visibility of the watermark mark which can be checked by looking is reduced by being spaced and attached and making image data operate an invisibility-ized matrix.
[0013] Furthermore, it is desirable to face [transforming inversely to said RGB system of color representation using an inverse transformation matrix] the image data of the YCbCr color coordinate system acquired by conversion by the transformation matrix for watermark embedding, and to perform underflow amendment and overflow amendment so that each pixel value in the image data of an RGB system of color representation may turn into an integral value of a predetermined range. If it carries out like this, the result of having transformed inversely can be dedicated within limits which the image data of an RGB system of color representation can take.
[0014] As for the real number value x of an augmented matrix, it is desirable to set it as the value of about 0.01 to about 0.7 range. If it carries out like this, since the incidence rate of underflow amendment or overflow amendment can be stopped small, deterioration of the substantial image quality by the embedding of a watermark mark can be reduced.
[0015] In addition, this invention is realizable in various modes, such as a computer program for realizing the function of the digital-watermarking method and equipment, its method, or equipment, a record medium which recorded the computer program, and a data signal embodied in the subcarrier including the computer program.
[0016]
[Embodiment of the Invention] A. Embedding processing of digital watermarking, and the principle of decode processing : explain the gestalt of operation of this invention hereafter based on an example. Drawing 1 is explanatory drawing of the principle of embedding processing of digital watermarking to the digital color picture in an example. Moreover, drawing 2 is explanatory drawing showing the contents of embedding processing.
[0017] Drawing 2 (A) shows the digital color picture which is a subject-copy image expressed by the RGB system of color representation. This subject-copy image P is defined as the aggregate of the pixel of a large number arranged in the shape of a matrix, and the magnitude of the subject-copy image P is prescribed by horizontal resolution Hsize and vertical definition Vsize. In addition, the unit of horizontal resolution or vertical definition is the number of pixels.
[0018] In this specification, the image data showing the color of each pixel of the subject-copy image P is defined by matrix =[P] [r, g, b] t (the alphabetic character with a top "t" shows a transposed matrix). the red (r) r, g, and whose b are the three primary colors of light here -- green -- (g) and blue (b) -- it is the brightness of each color component. The brightness of each color is expressed with predetermined resolution (for example, 256 gradation from zero to 255). Moreover, the YCbCr color coordinate system which specifies the color of each pixel and which consists of the luminance signal and two color-difference signals other than an RGB system of color representation if a color coordinate system is carried out is known widely. The image data which expresses the color of each pixel by the YCbCr color coordinate system in this specification is matrix =[F] [y, cb, cr] t. It defines.
[0019] These two color coordinate systems can be mutually changed reversibly by the chrominance-signal transformation matrix A and its inverse matrix A-1, as shown in the following (1a) and a formula (1b).
[0020]

[Equation 1]

$$F(i,j)=AP(i,j) \qquad (1a)$$

$$P(i,j)=A^{-1}F(i,j) \qquad (1b)$$

[0021] here, chrominance signals P and F are given -- **** (i, j) -- the location of a pixel is meant.

[0022] In this example, what is given by the following (2a) and the (2b) formula as a transformation matrix A and an inverse transformation matrix A-1 is used.

[0023]

[Equation 2]

$$A=\begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \qquad (2a)$$

$$A^{-1}=\begin{bmatrix} 1.000 & -0.001 & 1.402 \\ 1.000 & -0.344 & -0.714 \\ 1.000 & 1.772 & 0.001 \end{bmatrix} \qquad (2b)$$

[0024] In this example, it spaces, in case image data P of an RGB system of color representation is changed into image data F of a YCbCr color coordinate system, a mark is embedded, by transforming this inversely to an RGB system of color representation again, it is spaced and attached and an image is created. the transformation matrix (it is called "the transformation matrix for embedding") used for the embedding of a watermark mark is a thing (namely, (A+X)) adding the augmented matrix X given to a transformation matrix A by the following (3) formulas.

[0025]

[Equation 3]

$$X=\begin{bmatrix} 0 & -x & x \\ x & 0 & -x \\ -x & x & 0 \end{bmatrix} \qquad (3)$$

ここで、xは実数値である。

[0026] This augmented matrix X is a matrix in which the real number value x and -x are used as a component, and the sum of each line and the component of each train is set to 0. In addition, in this specification, a "watermark value" also calls a call and an augmented matrix X a "watermark matrix" for this real number value x. It opts for the configuration of such a watermark matrix X for the following reasons. First, it considers embedding so that a watermark mark cannot be checked by looking with the naked eye. For this reason, it is desirable to prevent the image quality deterioration by the pad of a watermark as much as possible. By the way, when each component of the transformation matrix A given by the formula (2a) is observed, it turns out that all the sums of the absolute value of the component of each line are 1. Therefore, also in the transformation matrix (A+X) for embedding, it is desirable to hold relation in which the sum of the absolute value of the component of each line is set to 1, when preventing image quality deterioration. (3) Since the watermark matrix X of a formula is set up so that the sum of each line and the component of each train may be set to 0, such a demand has been satisfied.

[0027] In case it spaces through the subject-copy image P and a mark is embedded, the mark image M which should be embedded and which spaces and includes a mark is prepared besides this subject-copy image P. An example of the mark image M used by this example is shown in drawing 2 (B). This mark image M is a binary image, the pixel value m in the field of two alphabetic characters "I" which constitute a watermark mark, and "T" is 1, and the pixel value m in other fields is 0. Below, the pixel value m only calls "the service area of a watermark mark", or a "mark field" and the field a call and whose pixel value m are 0 "the non-service area of a watermark mark" for the field which is 1. In addition, the service area of a watermark mark may

only be called a "watermark mark." For example, the **** "the location in a watermark mark" has the same semantics as "the location in the service area of a watermark mark."
[0028] The mark image M of this example has the same size as the subject-copy image P. However, the necessity of having the same size as the subject-copy image P does not have the mark image M, and the location of a watermark mark embedded in the subject-copy image M should just be determined by a certain method.
[0029] In case a watermark mark is embedded, according to the following (4a) and a formula (4b), conversion to a YCbCr color coordinate system from an RGB system of color representation is performed first.
[0030]
[Equation 4]

$$F_X(i,j)=(A+X)P(i,j) \quad ;m(i,j)=1 \qquad (4a)$$

$$F_X(i,j)=AP(i,j) \quad ;m(i,j)=0 \qquad (4b)$$

[0031] that is, in the pixel (pixel of m(i, j) = 1) of the location equivalent to the service area of a watermark mark, it spaced with the original transformation matrix A, and Matrix X was added -- embedding -- business -- conversion of a color coordinate system is performed using a transformation matrix (A+X). On the other hand, conversion of a color coordinate system is performed in the pixel (pixel of m(i, j) = 0) of the location equivalent to the non-service area of a watermark mark, using the original transformation matrix A as it is.
[0032] watermark information was embedded when data processing by (4a) and the formula (4b) was performed to all pixels -- spacing -- being attached -- YCbCr image data FX It is obtained (drawing 1 , drawing 2 (C)).
[0033] Next, this YCbCr image data FX with a watermark RGB-image-data PX with a watermark which will be given by the following (5a) and the formula (5b) if it receives and the inverse transformation matrix A-1 is made to operate it from the left It is obtained (drawing 1).
[0034]
[Equation 5]

$$P_X(i,j)=A^{-1}(A+X)P(i,j)$$

$$=P(i,j)+A^{-1}XP(i,j) \quad ;m(i,j)=1 \qquad (5a)$$

$$P_X(i,j)=A^{-1}AP(i,j)$$

$$=P(i,j) \quad ;m(i,j)=0 \qquad (5b)$$

[0035] It is spaced and attached as shown in this (5a) formula, and it is RGB-image-data PX. Original RGB-image-data P is overlapped on a noise component (A-1XP) in the service area of a watermark mark. Moreover, it is spaced and attached in the non-service area of a watermark mark, and is RGB-image-data PX. It has the value equal to original RGB-image-data P.
[0036] By the way, the sum of the component of each line of the watermark matrix X is 0 as shown in the above-mentioned (3) formula. Therefore, when the value of r of original RGB-image-data P (i, j), g, and b component is mutually equal (at namely, the time of an achromatic color), the noise component (A-1XP) of a formula (5a) will be set to 0. In order to prevent such a problem, as for a watermark mark, it is desirable to position to the field which is not an achromatic color in a subject-copy image.
[0037] In addition, drawing 2 (C) shows the condition that it is spaced and attached and the watermark mark in an image looks [****] thin. However, the visibility (the ease of carrying out of recognition by the naked eye) of a watermark mark can be adjusted by adjusting the watermark value x in the watermark matrix X in fact. About the method of adjustment of the visibility of a watermark mark, it mentions later further.
[0038] By the way, usually YCbCr image data consists of real number values to RGB image data consisting of integral values. Therefore, in case it changes into a YCbCr color coordinate system by (4a) and the formula (4b), real number-ization is performed, and integer-ization is performed in case it transforms inversely to an RGB system of color representation by (5a) and the formula

(5b). In the case of this integer-izing, the case where a pixel value serves as negative and an underflow is generated, and the case where it is overflowed exceeding the maximum of a pixel value occur. In order to solve this problem, in this example, underflow amendment and overflow amendment are performed in the case of integer-izing. That is, in performing underflow amendment set to 0 when the pixel value before integer-izing becomes negative, and exceeding the upper limit (for example, 255) of the bit expression, it performs overflow amendment which adopts the upper limit.

[0039] If underflow amendment and overflow amendment are performed, it will be spaced and attached and the substantial image quality of an image will be degraded. Here, "substantial deterioration" means deterioration of the image quality which cannot be recovered even if it eliminates a watermark mark. Since it originates in having spaced underflow amendment and overflow amendment through the original transformation matrix A, and having added Matrix X, the incidence rate of underflow amendment or overflow amendment spaces, and is dependent on the watermark value x which is the component of Matrix X. Therefore, as for the watermark value x, it is desirable to set it as a value which underflow amendment and overflow amendment seldom generate.

[0040] Drawing 3 is explanatory drawing showing the relation between the watermark value x and the incidence rate of underflow amendment and overflow amendment. "girl" and "graphic" which are the standard image used for the characterization of image quality here The result related with two images is shown. In addition, it is thought that results differ by the case where it is the case where the watermark value x is 0.1, and -0.1 because a bias is in distribution of the components r, g, and b of three colors in an image. The result of drawing 3 shows that it is desirable to set the watermark value x as about 0.7 or less value, in order to stop low the incidence rate of underflow amendment and overflow amendment. In addition, since it cannot space if the watermark value x is set as 0, and a mark cannot be embedded, it is desirable to set the watermark value x as about 0.01 or more values in fact. Therefore, it is desirable to set it as the value of about 0.01 - about 0.7 range as a watermark value x.

[0041] By the way, when [which it spaces and a mark cannot recognize with the naked eye] embedded, it will be necessary to restore the watermark mark. By being able to recognize with the naked eye, and twisting and spacing, a mark spaces, and it is attached, and is RGB-image-data PX. By using the noise component (A-1XP) contained, decoding by the following various methods is possible.

[0042] The 1st method is a method of performing color modification processing of an image so that it may be spaced and attached and the brightness value of each components r, g, and b of a RGB image may be raised to near the maximum. If it carries out like this, since a noise component (A-1XP) will also become large, it becomes easy to recognize a watermark mark with the naked eye.

[0043] The 2nd method is spaced, is attached and is RGB-image-data PX. It is the method of using the noise component (A-1XP) contained directly. That is, it is spaced and attached, using the subject-copy image data P as a key, and is RGB-image-data PX. A watermark mark (namely, watermark information) can be decoded by determining the field which sets and has a noise component (A-1XP). It is spaced and attached and, specifically, is RGB-image-data PX. It is possible to ask for difference (PX-P) with original RGB-image-data P, and to determine the field this difference (PX-P) of whose is not 0 as a mark field. In addition, difference (PX-P) is a matrix which has three components, r, g, and b, and **** "difference (PX-P) is not 0" means that at least one of the three components is not 0.

[0044] In addition, if the noise component (A-1XP) in a mark field is made to operate a transformation matrix A from the left, the product (XP) of the watermark matrix X and the subject-copy image data P will be obtained. If the subject-copy image data P is known, also when the watermark value x is unknown, it is possible to space from this product (XP) and to decode the watermark value x of Matrix X.

[0045] As mentioned above, a watermark mark can be embedded in a color picture by [which spaced through the transformation matrix A and added Matrix X] embedding and using the transformation matrix (A+X) of business. Moreover, the thing which it spaced, and it was

attached and was embedded from the image and which space and restores a mark is also possible.

[0046] B. adjustment [of the visibility of a watermark mark]: -- it mentioned above -- as -- spacing -- being attached -- RGB image PX **** -- in the mark field, it is superimposed on the noise component (A-1XP). Therefore, it is possible by adjusting the magnitude of the watermark value x and changing the value of a noise component (A-1XP) to adjust the visibility of a watermark mark.

[0047] Drawing 4 is explanatory drawing showing the adjustment method of the visibility of a watermark mark. The subject-copy image P of drawing 4 (A) and the mark image M of drawing 4 (B) are the same as what was shown in drawing 2 (A) and (B).

[0048] If the watermark value x is set as about about 0.7 comparatively big value, as shown in drawing 4 (C), it is spaced and attached and the watermark mark in an image can recognize clearly with the naked eye. Such a watermark mark is called "a visible watermark" on these specifications. If it spaces through a field with little change of color and a mark exists especially, change of the color in a mark field can be recognized more clearly. Therefore, in order to make a watermark mark easy to check by looking, it is desirable to space through a field with little change of color, and to position a mark.

[0049] When the watermark value x is set as about about 0.05 comparatively small value, it is spaced and attached and it becomes impossible on the other hand, for the watermark mark in an image to recognize with the naked eye, as shown in drawing 4 (E). Such a watermark mark is called "an invisible watermark" on these specifications. In addition, although the dotted line shows the appearance of a mark field in drawing 4 (E) in order to show the location of a watermark mark, it is possible to space through the degree which can hardly be recognized with the naked eye in fact, and to invisibility-ize a mark. Especially, lightness is in the orientation which cannot check a watermark mark by looking easily in a low field and the field of the chromatic color near an achromatic color. Therefore, in order to make a watermark mark hard to check by looking, it is desirable to space through the field where lightness is low, and the field of the chromatic color near an achromatic color, and to position a mark.

[0050] If the watermark value x is set as the in-between value of a visible watermark and an invisible watermark, a translucent watermark (it is called "a half-visible watermark") is generable. For example, if the watermark value x is set as about about 0.3 value, as shown in drawing 4 (D), it will be spaced and attached and the watermark mark in an image will become translucent.

[0051] Thus, it is possible by setting the watermark value x as a suitable value to set the visibility of a watermark mark as a desired degree.

[0052] By the way, it is possible by adjusting the array of the watermark matrix X to adjust the color of a watermark mark instead of adjusting the watermark value x as mentioned above. Namely, watermark matrix [1 and 3] 1 and X 2X which spaces and is illustrated by the following (6) types and (7) types instead of Matrix X as shown in (3) types If embedding processing used and mentioned above is performed, the color of a watermark mark will be changed.

[0053]

[Equation 6]

$$X_{1,2}=\begin{bmatrix} x & 0 & -x \\ 0 & -x & x \\ -x & x & 0 \end{bmatrix} \qquad (6)$$

[0054]

[Equation 7]

$$X_{1,3}=\begin{bmatrix} x & -x & 0 \\ -x & 0 & x \\ 0 & x & -x \end{bmatrix} \qquad (7)$$

[0055] (6) Watermark matrix 1 and X 2 of a formula The 1st line of the watermark matrix X of (3)

types and the 2nd line are replaced. Moreover, watermark matrix 1 and X 3 of (7) types The 1st line of the watermark matrix X of (3) types and the 3rd line are replaced. Generally it is possible by replacing the trains or lines of the watermark matrix X to change the color of a watermark mark so that these examples may show. In addition, if the color of a watermark mark is changed, the ease (namely, visibility) of carrying out of recognition by the naked eye will also change in many cases. So, on these specifications, changing the color of a watermark mark also corresponds to "adjustment of visibility" by replacing the trains or lines of a watermark matrix in this way.

[0056] C. Invisibility-ized processing of a visible watermark : a visible watermark can be invisibility-ized by processing of further the following. It is spaced and attached that a watermark mark can recognize with the naked eye so that he can understand from the formula (5a) mentioned above, and it is image data PX. It is because the noise component (A-1XP) is comparatively large. Therefore, it is possible to invisibility-ize a visible watermark by performing processing which reduces a noise component (A-1XP). In the case of this invisibility-ized processing, the invisibility-ized matrix K given by the following (8) formulas is used.

[0057]

[Equation 8]

$$K=(I+A^{-1}X)^{-1} \qquad (8)$$

[0058] Here, I is the unit matrix of 3x3. That is, the invisibility-ized matrix K is the unit matrix I and the inverse matrix of the sum (I+A-1X) of ** which space with the inverse transformation matrix A-1, and have the product (A-1X) of Matrix X, and a degree equal to a transformation matrix A.

[0059] About this invisibility-ized matrix K, as shown in drawing 5 , it is RGB-image-data PX with a watermark of a formula (5a). If it is operated, that addition result will be given by the following (9) formulas.

[0060]

[Equation 9]

$$\begin{aligned} K P_X(i,j) &= (I+A^{-1}X)^{-1}(I+A^{-1}X)P(i,j) \\ &= P'(i,j) \\ &\cong P(i,j) \end{aligned} \qquad (9)$$

[0061] Here, that the right-hand side of the 2nd line of (9) types is P' (i, j) means that it may not return to original image data P (i, j) completely according to the operation error in the middle of the embedding processing mentioned above (rounding error). That is, since integer-ization is performed when transforming inversely from a YCbCr signal to an RGB code, image data P' after invisibility-izing (i, j) may be unable to acquire the completely same value as the subject-copy image data P (i, j). However, since the error is a small amount below decimal point, with the naked eye, it is visible to the condition of not being different from a subject-copy image. [of the image after invisibility-izing] However, when the error by overflow amendment or underflow amendment is big, even if it performs invisibility-ization, it becomes impossible to return color to a dimension, and the trace of a watermark mark may be able to be checked by looking. Therefore, in order to be able to carry out [invisibility]-izing as completely as possible, it is desirable to use the small watermark value x of the degree which generates neither overflow amendment nor underflow amendment not much.

[0062] In addition, since image data P' after invisibility-izing includes the error in the mark field, it can decode a watermark mark also from image data P' after invisibility-izing. For example, image data P' after invisibility-izing and difference (P' - P) with the subject-copy image data P can be taken, and this difference (P' - P) can determine in 0 the field which is not as a mark field.

[0063] E. Improvement measure in security : one watermark value x was used for the whole watermark mark in above-mentioned explanation. When a third person gets to know the watermark value x temporarily, there is a possibility of a watermark of a false being created or

changing a watermark mark easily. Then, in order to strengthen the security of digital watermarking, it is desirable to apply two or more watermark values x in a mark image.
[0064] Drawing 6 is explanatory drawing showing the example which applied two or more watermark values x in the mark image. A different watermark value x1 to the mark field of two alphabetic characters "I" and "T" which constitutes a watermark mark from drawing 6 (A), and x2 It is applied. Moreover, a watermark value x1 which 2 sets of mark groups spatially separated in the mark image are arranged in drawing 6 (B), and is different to these two mark groups and x2 It is applied. In addition, it is also possible to consider that an alphabetic character "I" and "T" are a mutually different mark group also in the case of drawing 6 (A). That is, it is possible to set up a mutually different watermark value x to two or more mark groups generally separated spatially mutually. Since the visibility of a watermark mark changes according to the watermark value x as mentioned above, it is possible for it to be spaced and attached and to embed the mark group of various visibility in an image by setting up a watermark value x which is different in two or more mark groups in a mark image.
[0065] Drawing 7 is explanatory drawing showing the example of a partition of the mark field for a multiplex watermark. In the example of drawing 7 , the mark field which consists of one alphabetic character "T" is classified into two or more partition fields, and a different watermark value x is applied to the adjoining partition field. Various methods, such as the method of classifying with parallel lines like drawing 7 (A) as the partition method of a mark field and the method of classifying with a multiplex contour line-like border line like shown in drawing 7 (B), can be considered. In addition, "one mark field" means the service area which consists of pixels which continued spatially.
[0066] Since the watermark value x applied to each partition field can be kept secret by such multiplex watermark method, it is able for a third person to space and to prevent to discover a value x easily.
[0067] F. Whole equipment configuration and procedure : drawing 8 is the block diagram showing the configuration of the digital-watermarking processor which performs above-mentioned digital-watermarking processing by this example. This digital-watermarking processor is a computer equipped with CPU22, the main memory 24 containing ROM and RAM, a frame memory 26, a keyboard 30, a mouse 32, an indicating equipment 34, a hard disk 36, a modem 38, the scanner 39 that reads an image, and the bus 40 which connects each of these elements. In addition, various kinds of interface circuitries are omitted in drawing 8 . The modem 38 is connected to the computer network through the communication line which is not illustrated. The server which a computer network does not illustrate has a function as a program feeder which supplies a computer program to a digital-watermarking processor through a communication line.
[0068] The computer program for realizing the function of the digital-watermarking embedding section 42, the digital-watermarking decode section 44, the watermark visualization section 46, and ** is stored in main memory 24. It is as having spaced with the digital-watermarking embedding section 42 and the digital-watermarking decode section 44, and having already explained the function of the visualization section 46 in detail.
[0069] The computer program which realizes the function of these each part 42, 44, and 46 is offered with the gestalt recorded on the record medium which a flexible disk, CD-ROM, etc. can computer read. A computer reads a computer program in the record medium, and transmits it to internal storage or external storage. Or you may make it supply a computer program to a computer through a communication path. When realizing the function of a computer program, the computer program stored in internal storage is executed by the microprocessor of a computer. Moreover, a computer reads the computer program recorded on the record medium, and it may be made to carry out immediate execution.
[0070] In this specification, a computer is a concept containing hardware and operation system, and means the hardware which operates under control of operation system. Moreover, operation system is unnecessary, and when it seems that hardware is operated by the application program independent, the hardware itself is equivalent to a computer. Hardware is equipped with microprocessors, such as CPU, and the means for reading the computer program recorded on the record medium at least. The computer program contains in such a computer the program

code which realizes the function of each above-mentioned means. In addition, a part of above-mentioned function may be realized by not an application program but operation system. Furthermore, the program which performs embedding processing of digital watermarking, decode processing, and invisibility-ized processing of a watermark is good also as what is added in the form of plug-in to the program which performs an image processing.

[0071] In addition, as a "record medium" in this invention, computers, such as internal storage (memory, such as RAM and ROM) of the printed matter with which signs, such as a flexible disk, CD-ROM and a magneto-optic disk, an IC card, a ROM cartridge, a punch card, and a bar code, were printed, and a computer, and external storage, can use various data medium in which read is possible.

[0072] Drawing 9 is a flow chart which shows the procedure of the embedding processing which the embedding section 42 of digital watermarking performs. At step S1, the original RGB image P and the mark image M are prepared. At step S2, the transformation matrix A used for conversion of a color coordinate system and its inverse transformation matrix A-1 are prepared. At step S3, the watermark matrix X and the watermark value x are set up, respectively. In addition, a user is able to perform various setup which includes the adjustment of the visibility space and according to the value of a value x mentioned above, adjustment of the visibility by exchange of the lines of the watermark matrix X, or trains, and a setup of two or more watermark values x which can be set in a mark image at step S3.

[0073] At step S3, embedding processing mentioned above is performed using the transformation matrix (A+X) for embedding, and the inverse transformation matrix A-1. It is spaced and attached and an image is expressed on a display 34 as step S5. or it spaces, and it is attached and you may make it print an image by the printer which is not a drawing example At step S6, it spaces, it is attached and an image is observed, and if a user is this thing that can satisfy a result, he will end embedding processing. When it cannot be satisfied with a result, it spaces through step S3 with return and the watermark matrix X, a setup of a value x is changed, and step S4 and S5 are performed again. In this way, the thing for which the watermark mark of desired visibility was embedded and which spaces, are attached and creates an image is possible by repeating steps S3-S6.

[0074] in addition, as for decode of the watermark mark by the watermark decode section 44 (drawing 8), and invisibility-izing of the visible watermark by the watermark invisibility-ized section 46, the watermark mark was embedded -- it spaces, and it is attached and performs to an image if needed. Explanation of such procedure is omitted.

[0075] In addition, this invention can be carried out in various modes in the range which is not restricted to an above-mentioned example or an above-mentioned operation gestalt, and does not deviate from that summary, for example, the following deformation is also possible for it.

[0076] (1) You may make it transpose a part of configuration of that hardware was realized to software, and may make it transpose a part of configuration of that reverse was realized by software to hardware in the above-mentioned example. For example, it is also possible to space with the digital-watermarking embedding section 42 and the digital-watermarking decode section 44 which were realized by the computer program in drawing 8 , and to realize the function of the visualization section 46 by the hardware circuitry of respectively dedication.

[0077] (2) Although it spaced by transforming inversely once changing into a YCbCr color coordinate system from an RGB system of color representation and embedding of a mark was performed in the above-mentioned example, with this, embedding may be performed by transforming inversely conversely, once changing into an RGB system of color representation from a YCbCr color coordinate system. Moreover, it is possible to use two color coordinate systems of the arbitration which can perform reversibly not only these two color coordinate systems but conversion and inverse transformation as a color coordinate system which can be used.

[0078] (3) In the above-mentioned example, although conversion and inverse transformation were performed also with the pixel in the non-service area of a watermark mark using the transformation matrix A and the inverse transformation matrix A-1, respectively at the time of the embedding of a watermark mark, since it will return to subject-copy image data if inverse

transformation is performed about a non-service area, it may not be made not to perform such conversion or inverse transformation. In this case, by [which space and compounds the image data in a mark field to the subject-copy image data P (namely, overwrite)] having performed embedding processing mentioned above and having been obtained in this way about the service area of a watermark mark, it is spaced and attached and is image data PX. The whole can be obtained. What is necessary is just to perform inverse transformation using the conversion which used the transformation matrix (A+X) for embedding, and the inverse transformation matrix A-1 on the occasion of the embedding of a watermark mark about the pixel which spaces at least and is equivalent to the location in the service area of a mark, if it puts in another way.
[0079] (4) Although the above-mentioned example showed the example by which the watermark mark is constituted from a character string, as a watermark mark, it is possible to use the objects (natural drawing, an illustration, LOGO, etc.) of arbitration other than a character string.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, most proposals which are going to use the signal and data of a proper for a color picture, and are going to embed digital watermarking are not made. "depths information record of a color picture" (the **** society --) which used the color space of a color printer as digital-watermarking embedding technology The collection of annual meeting drafts, 7 and 20, pp.47-48, "a way method of the color watermark in consideration of a vision property" (IMPS 97, I-3.14, pp.45-46 (1997)) of model style molding which used the vision property skillfully, "A way method of the digital-watermarking embedding to a digital image" (SITA 97, Vol.2, pp.541-544 (1997)) is proposed. Such technology has a complicated model and has the weak spot where pad processing of a watermark is not easy. Moreover, degrading the image quality of a color picture was also pointed out by the method of embedding a watermark at the lower bit of a color picture.
[0005] This invention aims at offering the digital-watermarking technology for spacing through a color picture using the property of a proper, and embedding a mark.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Explanatory drawing showing the principle of embedding processing of digital watermarking which is one example of this invention.
[Drawing 2] Explanatory drawing showing the contents of embedding processing of digital watermarking.
[Drawing 3] Explanatory drawing showing relation with the incidence rate of the watermark value x, underflow amendment, and overflow amendment.
[Drawing 4] Explanatory drawing showing the adjustment method of the visibility of watermark information.
[Drawing 5] Explanatory drawing showing the principle of invisibility-ized processing of a visible watermark.
[Drawing 6] Explanatory drawing showing the example which applied two or more watermark values x in the mark image.
[Drawing 7] Explanatory drawing showing the example of a partition of the mark field for a multiplex watermark.
[Drawing 8] The block diagram showing the outline configuration of the digital-watermarking processor which performs digital-watermarking processing in an example.
[Drawing 9] The flow chart which shows the procedure of embedding processing of a watermark.
[Description of Notations]
22 -- CPU
24 -- Main memory
26 -- Frame memory
30 -- Keyboard
32 -- Mouse
34 -- Display
36 -- Hard disk
38 -- Modem
39 -- Scanner
40 -- Bus
42 -- Digital-watermarking embedding section
44 -- Digital-watermarking decode section
46 -- Watermark invisibility-ized section

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)**公開特許公報（Ａ）**　(11)特許出願公開番号
特開2000－358154
（P2000－358154A）
(43)公開日　平成12年12月26日(2000.12.26)

(51)Int.Cl.[7]	識別記号	ＦＩ		テーマコード(参考)
Ｈ０４Ｎ　1/387		Ｈ０４Ｎ　1/387		５Ｂ０５７
Ｇ０６Ｔ　1/00		Ｇ０９Ｃ　5/00		５Ｃ０７６
Ｇ０９Ｃ　5/00		Ｇ０６Ｆ　15/66	Ｂ	５Ｊ１０４
				９Ａ００１

審査請求　未請求　請求項の数９　ＯＬ　（全 11 頁）

(21)出願番号　特願平11－170816

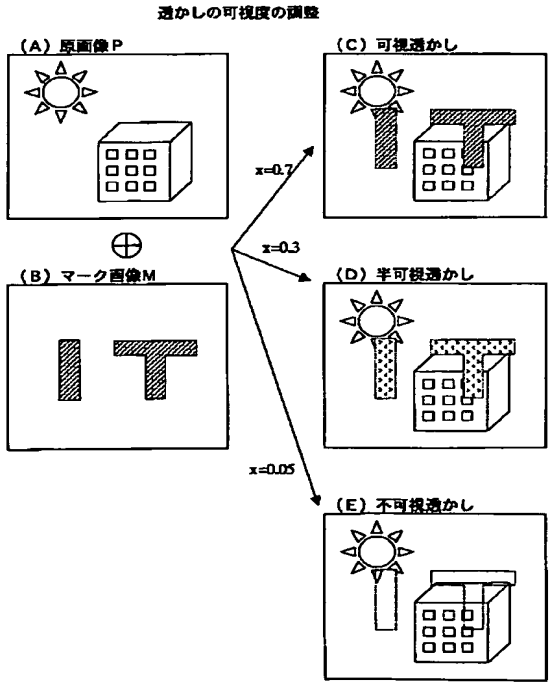
(22)出願日　平成11年６月17日(1999.6.17)

(71)出願人　000163006
興和株式会社
愛知県名古屋市中区錦３丁目６番29号
(72)発明者　松井　甲子雄
神奈川県横須賀市大津町５－57
(74)代理人　100096817
弁理士　五十嵐　孝雄　（外３名）

Ｆターム(参考)　5B057 CA01 CB01 CE08 CE18 CG07
5C076 AA14 AA26 BA06
5J104 AA14 NA27 PA07 PA14
9A001 EE02 HZ31 LL03

(54)【発明の名称】　透かしマークの可視度を調整可能な電子透かし

(57)【要約】
【課題】　カラー画像に固有の特性を利用して透かしマークを埋め込むための電子透かし技術を提供する。
【解決手段】　第１と第２の表色系の間の変換行列と逆変換行列とを準備し、また、実数値ｘおよび－ｘを成分とし、かつ、各行および各列の成分の和が略０となる付加行列を設定する。そして、変換行列に付加行列を加算することによって、透かし埋め込み用変換行列を作成する。次に、透かしマーク内の位置に相当する画素において、透かし埋め込み用変換行列を用いて第１の表色系の画像データを第２の表色系に変換する。この第２の表色系の画像データを第１の表色系に逆変換することによって、透かしマークが埋め込まれた透かし付き画像を表す透かし付き画像データを作成する。また、付加行列の設定の際に、実数値ｘと、付加行列内の各成分の配列とのうちの少なくとも一方を調整することによって、透かし付きカラー画像における透かしマークの可視度を調整する。



【特許請求の範囲】

【請求項１】　カラー画像に透かしマークの埋め込みを行う電子透かし方法であって、（ａ）第１の表色系のカラー画像データを前記第１の表色系とは異なる第２の表色系のカラー画像データに変換する変換行列と、前記変換の逆変換を行なう逆変換行列と、を準備する工程と、（ｂ）実数値ｘおよび－ｘを成分とし、かつ、各行および各列の成分の和が略０となる付加行列を設定する工程と、（ｃ）前記変換行列に前記付加行列を加算することによって、透かし埋め込み用変換行列を作成する工程と、（ｄ）カラー画像内に埋め込まれる透かしマークを準備する工程と、（ｅ）前記透かしマーク内の位置に相当する画素において、前記透かし埋め込み用変換行列を用いて前記第１の表色系のカラー画像データを前記第２の表色系に変換する工程と、（ｆ）前記変換により得られた第２の表色系のカラー画像データを、前記逆変換行列を用いて前記第１の表色系に逆変換することによって、前記透かしマークが埋め込まれた透かし付きカラー画像を表す透かし付き画像データを作成する工程と、を備え、

前記工程（ｂ）は、前記実数値ｘと、前記付加行列内の各成分の配列とのうちの少なくとも一方を調整することによって、前記透かし付きカラー画像における前記透かしマークの可視度を調整する工程を含むことを特徴とする電子透かし方法。

【請求項２】　請求項１記載の電子透かし方法であって、

前記透かしマークは、互いに空間的に分離された複数のマーク群を含み、

前記可視度の調整は、前記複数のマーク群のうちの少なくとも一部のマーク群において、前記実数値ｘを、他のマーク群と異なる値に設定することによって行われる、電子透かし方法。

【請求項３】　請求項１記載の電子透かし方法であって、

前記透かしマークは、空間的に連続した画素で構成されるマーク領域を含むとともに、前記マーク領域が複数の区分領域に区分されており、

前記可視度の調整は、前記複数の区分領域のうちの少なくとも一部の区分領域において、前記実数値ｘを、他の区分領域と異なる値に設定することによって行われる、電子透かし方法。

【請求項４】　請求項１記載の電子透かし方法であって、

前記可視度の調整は、前記付加行列の列同士または行同士を入れ替えることによって行われる、電子透かし方法。

【請求項５】　請求項１記載の電子透かし方法であって、

前記透かし付きカラー画像において前記透かしマークが肉眼で視認可能である場合に、

前記方法は、さらに、（ｇ）前記逆変換行列と前記付加行列の積と、前記変換行列と等しい次数を有する単位行列と、の和の逆行列である不可視化行列を準備する工程と、（ｈ）前記透かしマーク内の位置に相当する画素において、前記透かし付き画像データに前記不可視化行列を操作させることによって、前記視認可能な透かしマークの可視度を低下させる工程を含む、電子透かし方法。

【請求項６】　請求項１記載の電子透かし方法であって、

前記第１と第２の表色系の一方は、光の三原色を表す３つの色信号成分で構成されるＲＧＢ表色系であり、前記第１と第２の表色系の他方は、輝度信号と２つの色差信号成分とで構成されるＹＣｂＣｒ表色系である、電子透かし方法。

【請求項７】　請求項６記載の電子透かし方法であって、

前記工程（ｆ）は、前記透かし埋め込み用変換行列による変換によって得られた前記ＹＣｂＣｒ表色系の画像データを、前記逆変換行列を用いて前記ＲＧＢ表色系に逆変換するに際して、前記ＲＧＢ表色系の画像データにおける各画素値が所定範囲の整数値となるようにアンダフロー補正およびオーバフロー補正を行なう工程を含む、電子透かし方法。

【請求項８】　請求項１記載の電子透かし方法であって、

前記実数値ｘは、約０．０１から約０．７の範囲の値である、電子透かし方法。

【請求項９】　カラー画像に透かしマークの埋め込みを行うためのコンピュータプログラムを記録したコンピュータ読み取り可能な記録媒体であって、

実数値ｘおよび－ｘを成分とし、かつ、各行および各列の成分の和が略０となる付加行列を設定する機能と、

第１の表色系のカラー画像データを前記第１の表色系とは異なる第２の表色系のカラー画像データに変換するために予め準備された変換行列と、前記付加行列とを加算することによって透かし埋め込み用変換行列を作成する機能と、

前記透かし埋め込み用変換行列を用いて、予め準備された透かしマーク内の位置に相当する画素において、前記第１の表色系のカラー画像データを前記第２の表色系に変換する機能と、

前記変換により得られた第２の表色系のカラー画像データを、前記変換行列による変換の逆変換を行うために予め準備された逆変換行列を用いて前記第１の表色系に逆変換することによって、前記透かしマークが埋め込まれた透かし付きカラー画像を表す透かし付き画像データを作成する機能と、をコンピュータに実現させるためのコンピュータプログラムを記録しており、

前記付加行列設定機能は、前記実数値ｘと、前記付加行

列内の各成分の配列とのうちの少なくとも一方を調整することによって、前記透かし付きカラー画像における前記透かしマークの可視度を調整する機能を含むことを特徴とするコンピュータ読み取り可能な記録媒体。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、カラー画像に透かしマークを電子的に埋め込む電子透かし技術に関する。

【０００２】

【従来の技術】インターネットなどのコンピュータネットワークの発展に伴って、情報のデジタル化が進み、多くのユーザが簡単に必要とする情報にアクセスできるようになっている。その反面、そのデジタル情報に著作権が発生しているデジタルコンテンツについて、その著者に断わりなく容易にデータが複製できるような環境になりつつあり、不正コピーにともなう著作権侵害の問題が注目されてきている。そこで、デジタルコンテンツの主たる情報であるカラー画像に関しての著作権侵害を防止すること等を目的として、著作権情報などの透かし情報をカラー画像のデータに埋め込む電子透かし技術が注目されている。

【０００３】従来のこの種の電子透かしに関しては、濃淡画像に対して多くの技術的提案がなされている。カラー画像についても、その輝度成分（Ｙ成分）を考えれば、濃淡画像と同様に扱うことができるので、濃淡画像に対応する輝度成分に、電子透かしを埋め込む手法が用いられてきた。

【０００４】

【発明が解決しようとする課題】しかしながら、カラー画像に固有の信号やデータを用いて電子透かしを埋め込もうとする提案は、ほとんどなされていない。電子透かし埋め込み技術として、カラープリンタの色空間を利用した「カラー画像の深層情報記録」（画電学会、年次大会予稿集、７，２０，ｐｐ．４７－４８）、視覚特性を巧みに利用したモデル構成型の「視覚特性を考慮した色彩透かしの一手法」（ＩＭＰＳ　９７，Ｉ－３．１４，ｐｐ．４５－４６　（１９９７））、「デジタル画像への電子透かし埋め込みの一手法」（ＳＩＴＡ　９７，Ｖｏｌ．２，ｐｐ．５４１－５４４（１９９７））が提案されている。これらの技術は、モデルが煩雑で透かしの埋込み処理が簡単でないといった弱点をもっている。また、カラー画像の下位ビットに透かしを埋め込む方法では、カラー画像の画像品質を劣化させることも指摘されていた。

【０００５】本発明は、カラー画像に固有の特性を利用して透かしマークを埋め込むための電子透かし技術を提供することを目的とする。

【０００６】

【課題を解決するための手段およびその作用・効果】本発明では、第１の表色系のカラー画像データを、第１の表色系とは異なる第２の表色系のカラー画像データに変換する変換行列と、その変換の逆変換を行なう逆変換行列と、を準備する。また、実数値ｘおよび－ｘを成分とし、かつ、各行および各列の成分の和が略０となる付加行列を設定する。そして、変換行列に付加行列を加算することによって、透かし埋め込み用変換行列を作成する。次に、カラー画像内に埋め込まれる透かしマークを準備し、透かしマーク内の位置に相当する画素において、透かし埋め込み用変換行列を用いて第１の表色系のカラー画像データを第２の表色系に変換する。この変換により得られた第２の表色系のカラー画像データを、逆変換行列を用いて第１の表色系に逆変換することによって、透かしマークが埋め込まれた透かし付きカラー画像を表す透かし付き画像データを作成する。また、付加行列の設定の際に、実数値ｘと、付加行列内の各成分の配列とのうちの少なくとも一方を調整することによって、透かし付きカラー画像における透かしマークの可視度を調整する。

【０００７】本発明では、２つの表色系間の変換行列および逆変換行列と付加行列とを用いて変換と逆変換とを行うことによって、カラー画像に透かしマークを埋め込むことができる。付加行列の成分を規定する実数値ｘの値が変わると、透かしマークの色彩が変化する。また、付加行列の各成分の配列の変更によっても透かしマークの色彩が変化する。従って、付加行列の実数値ｘの値と、付加行列内の各成分の配列とのうちの少なくとも一方を調整することによって、透かしマークの可視度を調整することが可能である。

【０００８】ここで、第１または第２の表色系としては、光の三原色をパラメータとするＲＧＢ表色系や輝度信号および色差信号をパラメータとするＹＣｂＣｒ表色系を適宜採用することができる。これらの表色系は、画像データを扱う場合にしばしば用いられるものであり、かつ相互の変換行列が良く知られたものである。したがって、これからの画像データを取り扱うレタッチソフトなどが多数存在し、電子透かしを簡便に埋め込むことができる。

【０００９】なお、透かしマークは、互いに空間的に分離された複数のマーク群を含んでいてもよい。このとき、複数のマーク群のうちの少なくとも一部のマーク群において、実数値ｘを、他のマーク群と異なる値に設定することによって可視度の調整を行うことができる。こうすれば、可視度の異なる複数のマーク群をカラー画像内に埋め込むことが可能である。

【００１０】また、透かしマークは、空間的に連続した画素で構成されるマーク領域を含とともに、マーク領域が複数の区分領域に区分されていてもよい。このとき、複数の区分領域のうちの少なくとも一部の区分領域において、実数値ｘを、他の区分領域と異なる値に設定することによって可視度の調整を行うことができる。こうす

れば、可視度の異なる複数の区分領域で構成されたマーク領域を含むような透かしマークをカラー画像内に埋め込むことが可能である。

【００１１】可視度の調整は、前記付加行列の列同士または行同士を入れ替えることによって行うことが可能である。こうすれば、単に列同士または行同士の入れ替えによって、透かしマークを所望の可視度に設定することが可能である。

【００１２】なお、透かし付きカラー画像において透かしマークが肉眼で視認可能である場合には、透かしマークの可視度を低下させることも可能である。この際、まず、逆変換行列と前記付加行列の積と、変換行列と等しい次数を有する単位行列と、の和の逆行列である不可視化行列を準備する。そして、透かしマーク内の位置に相当する画素において、透かし付き画像データに不可視化行列を操作させることによって、視認可能な透かしマークの可視度を低下させる。

【００１３】更に、透かし埋め込み用変換行列による変換によって得られたＹＣｂＣｒ表色系の画像データを、逆変換行列を用いて前記ＲＧＢ表色系に逆変換するに際して、ＲＧＢ表色系の画像データにおける各画素値が所定範囲の整数値となるようにアンダフロー補正およびオーバフロー補正を行なうことが好ましい。こうすれば、ＲＧＢ表色系の画像データが採り得る範囲内に、逆変換した結果を納めることができる。

【００１４】付加行列の実数値ｘは、約０．０１から約０．７の範囲の値に設定することが好ましい。こうすれば、アンダーフロー補正やオーバーフロー補正の発生率を小さく抑えることができるので、透かしマークの埋め込みによる実質的な画質の劣化を低減することができる。

【００１５】なお、本発明は、電子透かし方法および装置、その方法または装置の機能を実現するためのコンピュータプログラム、そのコンピュータプログラムを記録した記録媒体、そのコンピュータプログラムを含み搬送波内に具現化されたデータ信号、等の種々の態様で実現することができる。

【００１６】

【発明の実施の形態】Ａ．電子透かしの埋め込み処理と復号処理の原理：以下、本発明の実施の形態を実施例に基づいて説明する。図１は、実施例におけるデジタルカラー画像への電子透かしの埋め込み処理の原理の説明図である。また、図２は、埋め込み処理の内容を示す説明図である。

【００１７】図２（Ａ）は、ＲＧＢ表色系で表現された原画像であるデジタルカラー画像を示している。この原画像Ｐは、マトリックス状に配置された多数の画素の集合体として定義されており、原画像Ｐの大きさは、水平解像度Hsizeと垂直解像度Vsizeによって規定されている。なお、水平解像度や垂直解像度の単位は、画素数である。

【００１８】本明細書において、原画像Ｐの各画素の色を表す画像データは、行列Ｐ＝［ｒ，ｇ，ｂ］^{t}（上付文字「^{t}」は転置行列を示す）で定義される。ここで、ｒ，ｇ，ｂは、光の三原色である赤（ｒ）、緑（ｇ）、青（ｂ）それぞれの色成分の輝度である。各色の輝度は、所定の分解能（例えば、０から２５５までの２５６階調）で表現される。また、各画素の色を規定する表色系しては、ＲＧＢ表色系の他に、輝度信号と２つの色差信号とで構成されるＹＣｂＣｒ表色系が広く知られている。本明細書において、ＹＣｂＣｒ表色系による各画素の色を表す画像データは、行列Ｆ＝［ｙ，ｃｂ，ｃｒ］^{t}で定義される。

【００１９】この２つの表色系は、下記の（１ａ），（１ｂ）式に示すように、色信号変換行列Ａと、その逆行列A^{-1}とによって相互に可逆的に変換することが可能である。

【００２０】

【数１】

$$F(i,j)=AP(i,j) \qquad (1a)$$

$$P(i,j)=A^{-1}F(i,j) \qquad (1b)$$

【００２１】ここで、色信号Ｐ，Ｆに付されている（ｉ，ｊ）は、画素の位置を意味している。

【００２２】本実施例では、変換行列Ａおよび逆変換行列A^{-1}として、以下の（２ａ），（２ｂ）式で与えられるものを使用する。

【００２３】

【数２】

$$A=\begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \qquad (2a)$$

$$A^{-1}=\begin{bmatrix} 1.000 & -0.001 & 1.402 \\ 1.000 & -0.344 & -0.714 \\ 1.000 & 1.772 & 0.001 \end{bmatrix} \qquad (2b)$$

【００２４】本実施例では、ＲＧＢ表色系の画像データＰをＹＣｂＣｒ表色系の画像データＦに変換する際に透かしマークを埋め込み、これを再度ＲＧＢ表色系に逆変換することによって透かし付き画像を作成する。透かしマークの埋め込みに使用される変換行列（「埋め込み用変換行列」と呼ぶ）は、変換行列Ａに、次の（３）式で与えられる付加行列Ｘを加算したもの（すなわち（Ａ＋Ｘ））である。

【００２５】

【数３】

$$X=\begin{bmatrix}0 & -x & x\\ x & 0 & -x\\ -x & x & 0\end{bmatrix} \qquad (3)$$

ここで、xは実数値である。

【００２６】この付加行列Xは、実数値xおよび－xを成分とし、かつ、各行および各列の成分の和が０となるような行列である。なお、本明細書においては、この実数値xを「透かし値」も呼び、また、付加行列Xを「透かし行列」とも呼ぶ。このような透かし行列Xの構成は、以下のような理由によって決定されている。まず、透かしマークを肉眼で視認できないように埋め込むことを考える。このためは、透かしの埋込みによる画質劣化をできるだけ防ぐことが好ましい。ところで、（２ａ）式で与えられる変換行列Aの各成分を観察すると、各行の成分の絶対値の和がすべて１となっていることが解る。従って、埋め込み用変換行列（Ａ＋Ｘ）においても、各行の成分の絶対値の和が１となるような関係を保持することが、画質劣化を防止する上で好ましい。（３）式の透かし行列Xは、各行および各列の成分の和が０となるように設定されているので、このような要求を満足している。

【００２７】原画像Pに透かしマークを埋め込む際には、この原画像Pの他に、埋め込まれるべき透かしマークを含むマーク画像Mを準備する。図２（Ｂ）には、本実施例で使用されるマーク画像Mの一例が示されている。このマーク画像Mは２値画像であり、透かしマークを構成する２つの文字「Ｉ」と「Ｔ」の領域における画素値mが１であり、その他の領域における画素値mは０である。以下では、画素値mが１である領域を「透かしマークの有効領域」または単に「マーク領域」と呼び、画素値mが０である領域を「透かしマークの非有効領域」と呼ぶ。なお、透かしマークの有効領域を単に「透かしマーク」と呼ぶこともある。例えば「透かしマーク内の位置」という文言は、「透かしマークの有効領域内の位置」と同じ意味を有している。

【００２８】本実施例のマーク画像Mは、原画像Ｐと同一のサイズを有している。但し、マーク画像Mが原画像Ｐと同一のサイズを有している必要は無く、原画像M内に埋め込まれる透かしマークの位置が何らかの方法で決定されていれば良い。

【００２９】透かしマークを埋め込む際には、まず、次の（４ａ），（４ｂ）式に従って、ＲＧＢ表色系からＹＣｂＣｒ表色系への変換が行われる。

【００３０】

【数４】

$$F_X(i,j)=(A+X)P(i,j) \quad ;m(i,j)=1 \qquad (4a)$$

$$F_X(i,j)=AP(i,j) \quad ;m(i,j)=0 \qquad (4b)$$

【００３１】すなわち、透かしマークの有効領域に相当する位置の画素（ｍ（ｉ，ｊ）＝１の画素）においては、元の変換行列Aと透かし行列Xとを加算した埋め込み用変換行列（Ａ＋Ｘ）を用いて表色系の変換が実行される。一方、透かしマークの非有効領域に相当する位置の画素（ｍ（ｉ，ｊ）＝０の画素）においては、元の変換行列Aをそのまま用いて表色系の変換が実行される。

【００３２】（４ａ），（４ｂ）式による演算処理をすべての画素に対して実行すると、透かし情報が埋め込まれた透かし付きＹＣｂＣｒ画像データF_Xが得られる（図１，図２（Ｃ））。

【００３３】次に、この透かし付きＹＣｂＣｒ画像データF_Xに対して逆変換行列A^{-1}を左から操作させると、次の（５ａ），（５ｂ）式で与えられる透かし付きＲＧＢ画像データP_Xが得られる（図１）。

【００３４】

【数５】

$$P_X(i,j)=A^{-1}(A+X)P(i,j)$$

$$=P(i,j)+A^{-1}XP(i,j) \quad ;m(i,j)=1 \qquad (5a)$$

$$P_X(i,j)=A^{-1}AP(i,j)$$

$$=P(i,j) \quad ;m(i,j)=0 \qquad (5b)$$

【００３５】この（５ａ）式に示されているように、透かし付きＲＧＢ画像データP_Xは、透かしマークの有効領域内において、原ＲＧＢ画像データＰにノイズ成分（$A^{-1}XP$）が重畳されたものである。また、透かしマークの非有効領域においては、透かし付きＲＧＢ画像データP_Xは原ＲＧＢ画像データＰと等しい値を有している。

【００３６】ところで、上記（３）式に示されているように、透かし行列Xの各行の成分の和は０である。従って、原ＲＧＢ画像データＰ（ｉ，ｊ）のｒ，ｇ，ｂ成分の値が互いに等しいとき（すなわち無彩色のとき）には、（５ａ）式のノイズ成分（$A^{-1}XP$）は０になってしまう。このような問題を防止するために、透かしマークは、原画像内の無彩色でない領域に位置決めしておくことが好ましい。

【００３７】なお、図２（Ｃ）では、透かし付き画像内の透かしマークが薄く見えているような状態を示している。しかし、実際には、透かしマークの可視度（肉眼による認識のし易さ）は、透かし行列Xにおける透かし値xを調整することによって調整可能である。透かしマー

クの可視度の調整の方法については、さらに後述する。

【００３８】ところで、ＲＧＢ画像データは整数値で構成されるのに対して、ＹＣｂＣｒ画像データは実数値で構成されるのが普通である。従って、（４ａ），（４ｂ）式によってＹＣｂＣｒ表色系に変換する際には実数化が行われ、（５ａ），（５ｂ）式によってＲＧＢ表色系に逆変換する際には整数化が行われる。この整数化の際には、画素値が負となってアンダフローを発生する場合や、画素値の上限を超えてオーバフローとなる場合が発生する。この問題を解決するため、本実施例では、整数化の際にアンダフロー補正およびオーバフロー補正を行う。すなわち、整数化前の画素値が負となった場合には０とするアンダーフロー補正を行い、また、そのビット表現の上限値（たとえば２５５）を超える場合にはその上限値を採用するオーバーフロー補正を行う。

【００３９】アンダーフロー補正やオーバーフロー補正を行うと、透かし付き画像の実質的な画質を劣化させる。ここで、「実質的な劣化」とは、透かしマークを消去しても回復できないような画質の劣化を意味する。アンダーフロー補正やオーバーフロー補正は、本来の変換行列Ａに透かし行列Ｘを加算したことに起因しているので、アンダーフロー補正やオーバーフロー補正の発生率は透かし行列Ｘの成分である透かし値ｘに依存する。従って、透かし値ｘは、アンダーフロー補正やオーバーフロー補正があまり発生しないような値に設定することが好ましい。

【００４０】図３は、透かし値ｘと、アンダーフロー補正およびオーバーフロー補正の発生率との関係を示す説明図である。ここでは、画質の特性評価用に用いられる標準画像である"girl"と"graphic" の２つの画像に関する結果が示されている。なお、透かし値ｘが０．１の場合と－０．１の場合とで結果が異なるのは、画像内における３色の成分ｒ，ｇ，ｂの分布に偏りがあるためであると考えられる。図３の結果から、アンダーフロー補正およびオーバーフロー補正の発生率を低く抑えるためには、透かし値ｘを約０．７以下の値に設定することが好ましいことが解る。なお、透かし値ｘを０に設定すると透かしマークを埋め込むことができないので、実際には透かし値ｘを約０．０１以上の値に設定することが好ましい。従って、透かし値ｘとしては約０．０１～約０．７の範囲の値に設定することが好ましい。

【００４１】ところで、埋め込まれた透かしマークが肉眼では認識できないときには、その透かしマークを復元する必要が生じる。肉眼で認識できない透かしマークは、透かし付きＲＧＢ画像データP_X に含まれるノイズ成分（$A^{-1}XP$）を利用することによって、以下のような種々の方法で復号することが可能である。

【００４２】第１の方法は、透かし付きＲＧＢ画像の各成分ｒ，ｇ，ｂの輝度値を最大値近くまで高めるように画像の色変更処理を行う方法である。こうすれば、ノイズ成分（$A^{-1}XP$）も大きくなるので、透かしマークが肉眼で認識し易くなる可能性がある。

【００４３】第２の方法は、透かし付きＲＧＢ画像データP_X に含まれるノイズ成分（$A^{-1}XP$）を直接的に利用する方法である。すなわち、原画像データＰを鍵として用いて、透かし付きＲＧＢ画像データP_X においてノイズ成分（$A^{-1}XP$）を有する領域を決定することによって、透かしマーク（すなわち透かし情報）を復号することができる。具体的には、透かし付きＲＧＢ画像データP_X と原ＲＧＢ画像データＰとの差分（P_X －Ｐ）を求め、この差分（P_X －Ｐ）が０でない領域をマーク領域として決定することが可能である。なお、差分（P_X －Ｐ）はｒ，ｇ，ｂの３つの成分を有する行列であり、「差分（P_X －Ｐ）が０でない」という文言は、３つの成分の少なくとも１つが０ではない、という意味である。

【００４４】なお、マーク領域におけるノイズ成分（$A^{-1}XP$）に変換行列Ａを左から操作させると、透かし行列Ｘと原画像データＰとの積（ＸＰ）が得られる。原画像データＰが既知であれば、透かし値ｘが不明な場合にも、この積（ＸＰ）から透かし行列Ｘの透かし値ｘを復号することが可能である。

【００４５】以上のように、変換行列Ａに透かし行列Ｘを加算した埋め込み用の変換行列（Ａ＋Ｘ）を用いることによって、透かしマークをカラー画像内に埋め込むことができる。また、透かし付き画像から、埋め込まれた透かしマークを復元することも可能である。

【００４６】Ｂ．透かしマークの可視度の調整：上述したように、透かし付きＲＧＢ画像P_X では、マーク領域においてノイズ成分（$A^{-1}XP$）が重畳されている。従って、透かし値ｘの大きさを調整してノイズ成分（$A^{-1}XP$）の値を変更することによって、透かしマークの可視度を調整することが可能である。

【００４７】図４は、透かしマークの可視度の調整方法を示す説明図である。図４（Ａ）の原画像Ｐおよび図４（Ｂ）のマーク画像Ｍは、図２（Ａ），（Ｂ）に示したものと同じである。

【００４８】透かし値ｘを約０．７程度の比較的大きな値に設定すると、図４（Ｃ）に示すように、透かし付き画像内の透かしマークがはっきりと肉眼で認識できる。このような透かしマークを、本明細書では「可視透かし」と呼ぶ。特に、色彩の変化が少ない領域に透かしマークが存在すると、マーク領域における色彩の変化を、よりはっきりと認識できる。従って、透かしマークを視認し易くするためには、色彩の変化が少ない領域に透かしマークを位置決めすることが好ましい。

【００４９】一方、透かし値ｘを約０．０５程度の比較的小さな値に設定すると、図４（Ｅ）に示すように、透かし付き画像内の透かしマークが肉眼では認識できなくなる。このような透かしマークを、本明細書では「不可

視透かし」と呼ぶ。なお、図4（E）では、透かしマークの位置を示すために、マーク領域の外形を点線で示しているが、実際には、ほとんど肉眼で認識できない程度に透かしマークを不可視化することが可能である。特に、明度が低い領域や、無彩色に近い有彩色の領域では、透かしマークを視認し難い傾向にある。従って、透かしマークを視認し難くするためには、明度が低い領域や、無彩色に近い有彩色の領域に透かしマークを位置決めすることが好ましい。

【0050】透かし値xを、可視透かしと不可視透かしの中間的な値に設定すると、半透明な透かし（「半可視透かし」と呼ぶ）を生成することができる。例えば、透かし値xを約0．3程度の値に設定すると、図4（D）に示すように、透かし付き画像内の透かしマークが半透明になる。

【0051】このように、透かし値xを適切な値に設定することによって、透かしマークの可視度を所望の程度に設定することが可能である。

【0052】ところで、上述のように透かし値xを調整する代わりに、透かし行列Xの配列を調整することによって、透かしマークの色を調整することが可能である。すなわち、（3）式に示した透かし行列Xの代わりに、次の（6）式および（7）式に例示されるような透かし行列$X_{1,2}$，$X_{1,3}$を用いて上述した埋め込み処理を行えば、透かしマークの色が変更される。

【0053】

【数6】

$$X_{1,2}=\begin{bmatrix} x & 0 & -x \\ 0 & -x & x \\ -x & x & 0 \end{bmatrix} \tag{6}$$

【0054】

【数7】

$$X_{1,3}=\begin{bmatrix} x & -x & 0 \\ -x & 0 & x \\ 0 & x & -x \end{bmatrix} \tag{7}$$

【0055】（6）式の透かし行列$X_{1,2}$は、（3）式の透かし行列Xの第1行目と第2行目を入れ替えたものである。また、（7）式の透かし行列$X_{1,3}$は、（3）式の透かし行列Xの第1行目と第3行目を入れ替えたものである。これらの例から解るように、一般には、透かし行列Xの列同士または行同士を入れ替えることによって、透かしマークの色を変更することが可能である。なお、透かしマークの色を変えると、肉眼による認識のし易さ（すなわち可視度）も変わることが多い。そこで、本明細書では、このように透かし行列の列同士または行同士を入れ替えることによって、透かしマークの色を変更することも、「可視度の調整」に該当する。

【0056】C．可視透かしの不可視化処理：可視透かしは、更に、以下の処理によって不可視化することが可能である。前述した（5a）式から理解できるように、透かしマークが肉眼で認識できるのは、透かし付き画像データP_Xのノイズ成分（$A^{-1}XP$）が比較的大きいからである。従って、ノイズ成分（$A^{-1}XP$）を低減する処理を実行することによって、可視透かしを不可視化することが可能である。この不可視化処理の際には、次の（8）式で与えられる不可視化行列Kを用いる。

【0057】

【数8】

$$K=(I+A^{-1}X)^{-1} \tag{8}$$

【0058】ここで、Iは3×3の単位行列である。すなわち、不可視化行列Kは、逆変換行列A^{-1}と透かし行列Xの積（$A^{-1}X$）と、変換行列Aと等しい次数を有する単位行列Iと、の和（$I+A^{-1}X$）の逆行列である。

【0059】この不可視化行列Kを、図5に示すように、（5a）式の透かし付きRGB画像データP_Xに操作すれば、その積算結果が以下の（9）式で与えられる。

【0060】

【数9】

$$\begin{aligned} KP_X(i,j) &= (I+A^{-1}X)^{-1}(I+A^{-1}X)P(i,j) \\ &= P'(i,j) \\ &\cong P(i,j) \end{aligned} \tag{9}$$

【0061】ここで、（9）式の2行目の右辺がP'（i，j）となっているのは、上述した埋め込み処理の途中における演算誤差（丸め誤差）によって、完全には元の画像データP（i，j）には戻らないことがあることを意味している。すなわち、YCbCr信号からRGB信号に逆変換するときに整数化が行われるので、不可視化後の画像データP'（i，j）が原画像データP（i，j）と全く同じ値を得ることはできないことがある。しかし、その誤差は、小数点以下の小さな量なので、肉眼では、不可視化後の画像が原画像と変わらない状態に見える。しかし、オーバーフロー補正やアンダーフロー補正による誤差が大きなときには、不可視化を行っても色彩を元にもどせなくなり、透かしマークの形跡が視認できることもある。従って、なるべく完全に不可視化できるようにするためには、オーバーフロー補正やアンダーフロー補正をあまり発生させない程度の小さな透かし値xを用いておくことが好ましい。

【0062】なお、不可視化後の画像データP'は、マーク領域において誤差を含んでいるので、不可視化後の画像データP'からも、透かしマークを復号することが可能である。例えば、不可視化後の画像データP'と原画像データPとの差分（P'－P）をとり、この差分（P'－P）が0では無い領域を、マーク領域と決定す

ることができる。

【００６３】Ｅ．セキュリティ向上策：上述の説明では、透かしマークの全体に１つの透かし値ｘを用いていた。仮に透かし値ｘを第三者に知られた場合には、偽の透かしが作成されたり、透かしマークを容易に変更されたりするおそれがある。そこで、電子透かしのセキュリティを強化するために、マーク画像内に複数の透かし値ｘを適用することが好ましい。

【００６４】図６は、マーク画像内に複数の透かし値ｘを適用した例を示す説明図である。図６（Ａ）では、透かしマークを構成する２つの文字「Ｉ」，「Ｔ」のマーク領域に対して、異なる透かし値x_1，x_2が適用されている。また、図６（Ｂ）では、マーク画像内に、空間的に分離された２組のマーク群が配置されており、これらの２つのマーク群に対して異なる透かし値x_1，x_2が適用されている。なお、図６（Ａ）の場合にも、文字「Ｉ」と「Ｔ」を、互いに異なるマーク群であると考えることも可能である。すなわち、一般に、互いに空間的に分離された複数のマーク群に対して、互いに異なる透かし値ｘを設定することが可能である。上述したように、透かしマークの可視度は透かし値ｘに応じて変わるので、マーク画像内の複数のマーク群に異なる透かし値ｘを設定することによって、様々な可視度のマーク群を透かし付き画像内に埋め込むことが可能である。

【００６５】図７は、多重透かしのためのマーク領域の区分例を示す説明図である。図７の例では、１つの文字「Ｔ」で構成されるマーク領域が、複数の区分領域に区分されており、隣接する区分領域には異なる透かし値ｘが適用されている。マーク領域の区分方法としては、図７（Ａ）のように平行線で区分する方法や、図７（Ｂ）に示すように等高線状の多重輪郭線によって区分する方法などの種々の方法が考えられる。なお、「１つのマーク領域」とは、空間的に連続した画素で構成される有効領域を意味している。

【００６６】このような多重透かし方法では，各区分領域に適用されている透かし値ｘを秘匿できるので、第三者が透かし値ｘを容易に発見できないようにすることが可能である。

【００６７】Ｆ．装置の全体構成と処理手順：図８は、本実施例による上述の電子透かし処理を実行する電子透かし処理装置の構成を示すブロック図である。この電子透かし処理装置は、ＣＰＵ２２と、ＲＯＭおよびＲＡＭを含むメインメモリ２４と、フレームメモリ２６と、キーボード３０と、マウス３２と、表示装置３４と、ハードディスク３６と、モデム３８と、画像を読み取るスキャナ３９と、これらの各要素を接続するバス４０と、を備えるコンピュータである。なお、図８では各種のインターフェイス回路は省略されている。モデム３８は、図示しない通信回線を介してコンピュータネットワークに接続されている。コンピュータネットワークの図示しないサーバは、通信回線を介してコンピュータプログラムを電子透かし処理装置に供給するプログラム供給装置としての機能を有する。

【００６８】メインメモリ２４には、電子透かし埋め込み部４２と、電子透かし復号部４４と、透かし可視化部４６と、の機能を実現するためのコンピュータプログラムが格納されている。電子透かし埋め込み部４２と電子透かし復号部４４と透かし可視化部４６の機能については既に詳しく説明した通りである。

【００６９】これらの各部４２，４４，４６の機能を実現するコンピュータプログラムは、フレキシブルディスクやＣＤ－ＲＯＭ等の、コンピュータ読み取り可能な記録媒体に記録された形態で提供される。コンピュータは、その記録媒体からコンピュータプログラムを読み取って内部記憶装置または外部記憶装置に転送する。あるいは、通信経路を介してコンピュータにコンピュータプログラムを供給するようにしてもよい。コンピュータプログラムの機能を実現する時には、内部記憶装置に格納されたコンピュータプログラムがコンピュータのマイクロプロセッサによって実行される。また、記録媒体に記録されたコンピュータプログラムをコンピュータが読み取って直接実行するようにしてもよい。

【００７０】この明細書において、コンピュータとは、ハードウェア装置とオペレーションシステムとを含む概念であり、オペレーションシステムの制御の下で動作するハードウェア装置を意味している。また、オペレーションシステムが不要でアプリケーションプログラム単独でハードウェア装置を動作させるような場合には、そのハードウェア装置自体がコンピュータに相当する。ハードウェア装置は、ＣＰＵ等のマイクロプロセッサと、記録媒体に記録されたコンピュータプログラムを読み取るための手段とを少なくとも備えている。コンピュータプログラムは、このようなコンピュータに、上述の各手段の機能を実現させるプログラムコードを含んでいる。なお、上述の機能の一部は、アプリケーションプログラムでなく、オペレーションシステムによって実現されていても良い。更に、電子透かしの埋め込み処理や復号処理、透かしの不可視化処理を行なうプログラムは、画像処理を行なうプログラムに対して、プラグインの形式で付加されるものとしてもよい。

【００７１】なお、この発明における「記録媒体」としては、フレキシブルディスクやＣＤ－ＲＯＭ、光磁気ディスク、ＩＣカード、ＲＯＭカートリッジ、パンチカード、バーコードなどの符号が印刷された印刷物、コンピュータの内部記憶装置（ＲＡＭやＲＯＭなどのメモリ）および外部記憶装置等の、コンピュータが読取り可能な種々の媒体を利用することができる。

【００７２】図９は、電子透かしの埋め込み部４２が行う埋め込み処理の手順を示すフローチャートである。ステップＳ１では、原ＲＧＢ画像Ｐと、マーク画像Ｍとを

準備する。ステップＳ２では、表色系の変換に用いる変換行列Ａと、その逆変換行列A^{-1}とを準備する。ステップＳ３では、透かし行列Ｘと、透かし値ｘとをそれぞれ設定する。なお、ステップＳ３では、上述した透かし値ｘの値による可視度の調整と、透かし行列Ｘの行同士または列同士の入れ替えによる可視度の調整と、マーク画像内における複数の透かし値ｘの設定とを含む種々の設定をユーザが行うことが可能である。

【００７３】ステップＳ３では、埋め込み用変換行列（Ａ＋Ｘ）と逆変換行列A^{-1}とを用いて、上述した埋め込み処理を実行する。ステップＳ５では、透かし付き画像がディスプレイ３４に表示される。あるいは、透かし付き画像を図示しないプリンタで印刷するようにしてもよい。ステップＳ６では、ユーザが、この透かし付き画像を観察し、結果が満足できるものであれば、埋め込み処理を終了する。結果に満足できないときは、ステップＳ３に戻り、透かし行列Ｘと透かし値ｘの設定を変更して、再度ステップＳ４，Ｓ５を実行する。こうして、ステップＳ３～Ｓ６を繰り返すことによって、所望の可視度の透かしマークが埋め込まれた透かし付き画像を作成することが可能である。

【００７４】なお、透かし復号部４４（図８）による透かしマークの復号や、透かし不可視化部４６による可視透かしの不可視化は、透かしマークが埋め込まれた透かし付き画像に対して、必要に応じて実行される。これらの処理手順の説明は省略する。

【００７５】なお、この発明は上記の実施例や実施形態に限られるものではなく、その要旨を逸脱しない範囲において種々の態様において実施することが可能であり、例えば次のような変形も可能である。

【００７６】（１）上記実施例において、ハードウェアによって実現されていた構成の一部をソフトウェアに置き換えるようにしてもよく、逆に、ソフトウェアによって実現されていた構成の一部をハードウェアに置き換えるようにしてもよい。例えば、図８においてコンピュータプログラムで実現されていた電子透かし埋め込み部４２と電子透かし復号部４４と透かし可視化部４６の機能を、それぞれ専用のハードウェア回路で実現することも可能である。

【００７７】（２）上記実施例では、ＲＧＢ表色系からＹＣｂＣｒ表色系に一旦変換した後に逆変換することによって透かしマークの埋め込みを行っていたが、これとは逆に、ＹＣｂＣｒ表色系からＲＧＢ表色系に一旦変換した後に逆変換することによって埋め込みを行っても良い。また、利用できる表色系としてはこれらの２つの表色系に限らず、変換と逆変換を可逆的に行いうる任意の２つの表色系を利用することが可能である。

【００７８】（３）上記実施例では、透かしマークの埋め込み時に、透かしマークの非有効領域内の画素についても、変換行列Ａと逆変換行列A^{-1}を用いて変換と逆変換をそれぞれ行っていたが、非有効領域については逆変換を行うと原画像データに戻るので、このような変換や逆変換を行わないようにしても良い。この場合には、透かしマークの有効領域について上述した埋め込み処理を行い、こうして得られた透かしマーク領域内の画像データを原画像データＰに合成（すなわち上書き）することによって、透かし付き画像データP_Xの全体を得ることができる。換言すれば、透かしマークの埋め込みに際しては、少なくとも透かしマークの有効領域内の位置に相当する画素について、埋め込み用変換行列（Ａ＋Ｘ）を用いた変換と、逆変換行列A^{-1}とを用いた逆変換とを行えばよい。

【００７９】（４）上記実施例では、透かしマークが文字列で構成されている例を示したが、透かしマークとしては、文字列以外の任意のオブジェクト（自然画、イラスト、ロゴ等）を用いることが可能である。

【図面の簡単な説明】

【図１】本発明の一実施例である電子透かしの埋め込み処理の原理を示す説明図。

【図２】電子透かしの埋め込み処理の内容を示す説明図。

【図３】透かし値ｘとアンダーフロー補正およびオーバーフロー補正の発生率との関係を示す説明図。

【図４】透かし情報の可視度の調整方法を示す説明図。

【図５】可視透かしの不可視化処理の原理を示す説明図。

【図６】マーク画像内に複数の透かし値ｘを適用した例を示す説明図。

【図７】多重透かしのためのマーク領域の区分例を示す説明図。

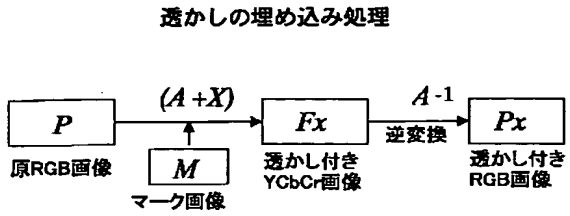
【図８】実施例における電子透かし処理を実行する電子透かし処理装置の概略構成を示すブロック図。

【図９】透かしの埋め込み処理の手順を示すフローチャート。

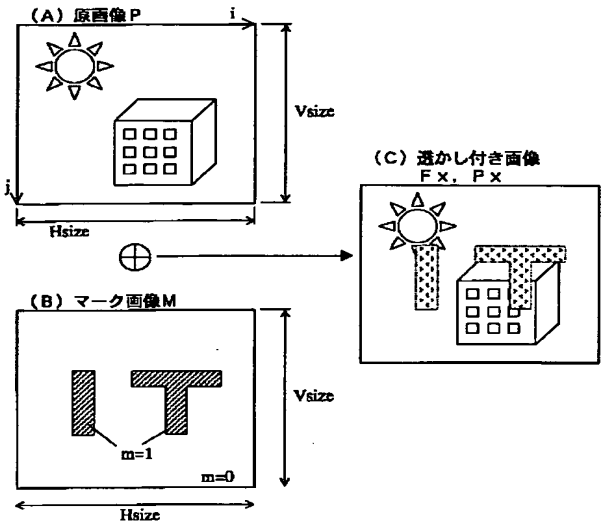
【符号の説明】

２２…ＣＰＵ
２４…メインメモリ
２６…フレームメモリ
３０…キーボード
３２…マウス
３４…表示装置
３６…ハードディスク
３８…モデム
３９…スキャナ
４０…バス
４２…電子透かし埋め込み部
４４…電子透かし復号部
４６…透かし不可視化部

【図１】



【図２】



【図３】

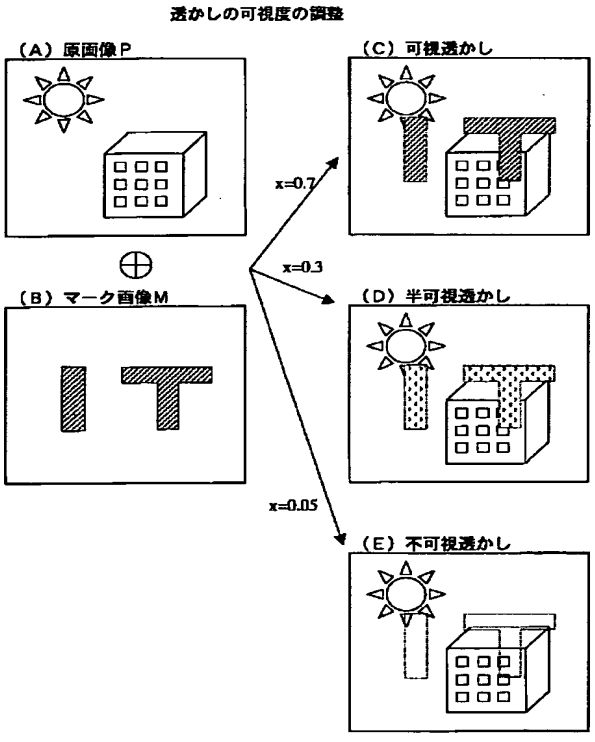
(A) 画像"girl"に対するアンダーフローおよびオーバーフロー発生率

透かし値x	r	g	b
0.9	13.02%	0.31%	0.79%
0.7	0%	0%	0.31%
0.5	0%	0%	0.08%
0.3	0%	0%	0%
0.1	0%	0%	0%
-0.1	0.01%	1.67%	11.94%
-0.3	0.79%	10.44%	20.47%

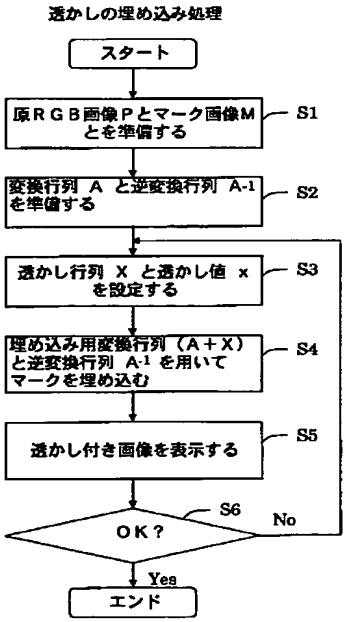
(B) 画像"graphic"に対するアンダーフローおよびオーバーフロー発生率

透かし値x	r	g	b
0.9	30.60%	18.83%	17.43%
0.7	0%	0.42%	14.38%
0.5	0%	0%	12.00%
0.3	0%	0%	4.90%
0.1	0%	0%	0.04%
-0.1	6.43%	1.73%	30.34%
-0.3	24.56%	14.05%	33.78%

【図４】

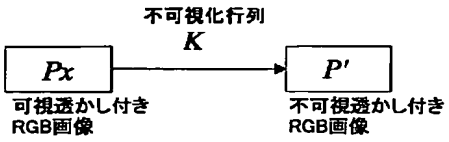


【図９】



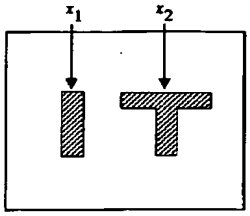
【図５】

可視透かしの不可視化処理

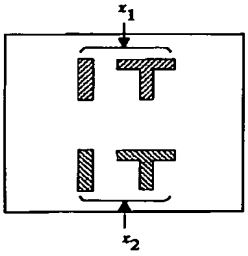


【図６】

（Ａ）マーク領域毎に異なる透かし値ｘを適用する例

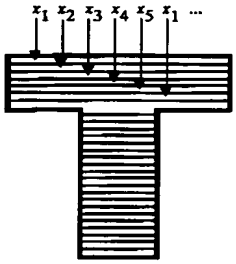


（Ｂ）複数のマーク群に異なる透かし値ｘを適用する例

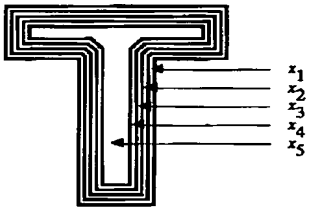


【図７】

（Ａ）多重透かしのためのマーク領域の区分例１



（Ｂ）多重透かしのためのマーク領域の区分例２



【図８】